SCIENTIFIC AMERICAN SUPPLEMENT. No. 1189

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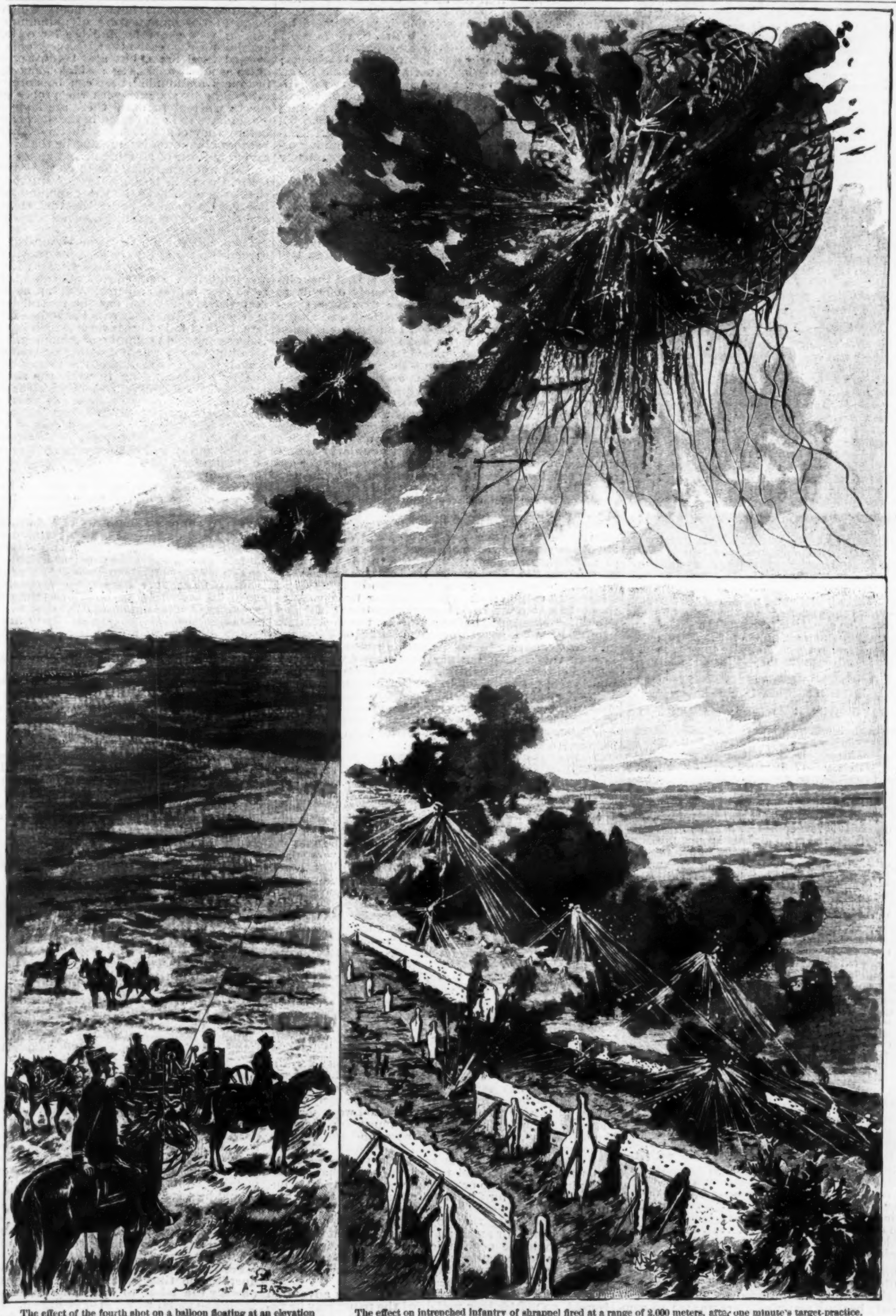
Scientific American, established 1845.
Scientific American Supplement, Vol. XLVI, No. 1189.

NEW YORK, OCTOBER 15, 1898.

Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.



The effect of the fourth shot on a balloon floating at an elevation of 600 meters and range of 6,000 meters.

The effect on intrenched infantry of shrapnel fired at a range of 2,000 meters, after one minute's target-practice. The black dots indicate the hits.

TESTING THE NEW FRENCH 7·5-cm. FIELD-PIECE AT CHÂLONS.

A NEW FIELD-PIECE FOR THE FRENCH ARMY.

The artillery of the French army is soon to be equipped with a new field-piece. One of the illustrations presented herewith shows the effect of this gun when fired at a range of 2,500 meters (2,735 yards) after having been in action for one minute in order to get the range. Wooden models representing infantry, partly intrenched and partly unprotected, were stationed as shown in the smaller engraving. The black points indicated, represent the hits made by shrapnel-balls or pieces of shell. The upper engraving represents one of the tests made at Châlons and shows the destructive effect of the last of four shots fired by this piece at a range of 6,000 meters (6,364 yards) when trained on a captive balloon floating in the air at an elevation of 600 meters (1,968 feet) and pulled along by a wagon.

For the past five years, the French government has been making experiments with rapid-fire field-pieces. Although the experiments were secretly performed, the French press so early as 1894 was busily engaged in proclaiming to the world that their government contemplated the introduction of a new rapid-fire field-piece. Minister after minister visited the proving grounds at Châlons or Bourges, and witnessed the tests. The commission that conducted the experiments, several times had the pleasure of receiving visits from the President of the Republic, although he as well as Cavaignac, Minister of War at the time, knew nothing of matters pertaining to artillery.

The new field-piece has a caliber of 7·5 centimeters (2·95 inches). The gun is made entirely of nickel-steel and is provided with the usual breech-closing mechanism. In loading the piece, the gunner first removes the empty shell. After inserting a new projectile, he closes the breech by swinging the breech-plug into position and screwing it into the screw-box. Simultaneously with this action, the hammer is cocked. The piece is sighted and fired by a man who sits to the right of the gun-carriage. In action, the gun is first roughly trained on the target by an artilleryman who, by operating a lever on the rear portion of the carriage, turns the whole piece to the right or to the left; the finer adjustments are made by turning the gun itself on the carriage.

When a projectile is discharged from the gun, the carriage shows a tendency to recoil. In addition to this, the gun itself springs back on the carriage, but is returned to its initial position by a recoil-cylinder containing glycerin. A similar system of hydro-pneumatic recoil-cylinders is also applied to the 12 centimeter (4·724 inch) field-howitzer. In order to counteract the recoil of the carriage, a strong spike is secured to the rear end of the carriage, which spike after the first few shots have been fired embeds itself firmly in the soil, and thus prevents the carriage from changing its position.

The rapidity of fire of this piece depends chiefly on the use of fixed ammunition and on the possibility of simultaneously loading and sighting the piece. Ordinarily the gun can fire five shots per minute, and if ammunition could be served quickly enough, twenty shots per minute.

The projectiles used are explosive shells filled with melinite and double-fused shrapnels containing about 250 lead balls. The shrapnel explodes at a short distance from the target, scattering the lead balls to each side. This scattering is increased by swinging the gun from side to side while firing, a movement which has been likened to the action of a scythe and which has hence been termed *faucher le terrain*. In the accompanying illustration this swinging of the piece on its carriage has been presupposed in order to produce the highly destructive effect indicated.—Illustrirte Zeitung.

BLACK PRINT PROCESSES.

By Albert E. Guy, in American Machinist.

The water bath black print paper is made in two ways:

First Process.—After sensitizing the paper with an appropriate solution gallic acid, very dry, is rubbed by hand against its surface, or the paper is made to pass between two rollers, which press the acid against it, a felt roller or a long brush removing afterward the excess of acid. Such prepared paper can be used advantageously when only a few copies of a tracing are required, but if it is necessary to make a large number of prints from the same tracing, this latter must be well brushed after each exposure, because the pressure of the glass in the printing frame to which it is subjected tends to apply a coating of acid to its under side. This acid prevents the light from acting upon the sensitized paper, and consequently, on developing, large black clouds are seen on the print, giving it a dirty appearance and blurring the lines.

The hands of the operator, impregnated by the gallic acid, are blackened by the contact of any article of iron, and the color is quite hard to remove.

A formula called the Shawcross is generally used to make the sensitized solution, and for the benefit of those who want to try this process it is given here:

	Grammes.
Water	11,000
Gelatine	1,500
Iron chloride	1,500
Iron sulphate	600
Tartaric acid	188
Sodium chloride	940

This solution is very thick; it is quite evident that the quantity of water is not sufficient. I have never been able to make a success with the above proportions, but have obtained very good results with the following:

	Parts.
Water	280
Gelatine	15
Tartaric acid	2
Sodium chloride	9·2
Iron chloride	15
Tersulphate of iron solution	21

If the gallic acid is applied as soon as the sensitized paper is dried, it will adhere to the surface, but it is very difficult to apply it uniformly. This process is employed only because manufacturers wanted to comply with their customers' wishes, and, not being able to produce a direct water bath paper, compromised by bringing forward this article.

When developing the print, the water must not be squirted upon the sheet for fear of washing away the gallic acid. It is preferable to lay the sheet in a shallow tray containing fresh water; after washing for five or six minutes, hang up to dry.

Second Process.—When experimenters try at first to find this process, they generally begin by utilizing the acid bath solution, thinking that it is only necessary to add to it the developer. This developer is either gallic acid or tannic acid. As no method is followed for experimenting, the results are discouraging, and soon the searchers are looking for a substance having the property of preventing the reaction of the tannin on the iron salts in the solution and upon the sensitized paper, while after exposure the said substance must become neutral to the action of those chemicals; and they try everything they can think of. If they follow a method, they study the properties of the acids and become convinced that the task is not possible unless chance favors.

Tannic acid in aqueous solution is precipitated by the following acids: Sulphuric, hydrochloric, arsenic, phosphoric, boric. The precipitates have long been considered as combinations of the tannin and the acids; they are white, soluble in water, and insoluble in an excess of acids; but recent experiments seem to indicate that they are produced only by the tannin, which, being less soluble in the acid solutions than in pure water, deposits when any energetic acid is added. Nitric acid transforms the tannin into oxalic acid. Tannic acid precipitates nearly all the salts containing organic alkalies. Gelatinous solutions are completely precipitated by tannin. The two last reactions are not shared by gallic acid, while the first ones are.

It is quite hard to imagine a substance, neither acid nor alkaline, capable of preventing the reactions between the iron salts and the tannin. As for gallic acid, since it reduces the ferric salts into ferrous, it is itself reduced—that is, it loses some oxygen; the only way to bring the iron salts into their former state is to boil the solution.

The inconvenience of this method is that the solution deposits very soon and is extremely difficult to keep in good condition. Having made over three thousand experiments with numerous chemicals and all the papers available on the market, I am of the opinion that the tannic process is the best.

While studying the properties of the iron salts, gum arabic, and tartaric acid, I found that a solution containing iron perchloride and gum arabic, when spread on paper and dried, produces an insoluble film, even in hot water, whereas a solution with iron perchloride, gum arabic, and tartaric acid forms a nearly insoluble film, as found by Poitevin. When dipped, even in cold water, the film dissolves to some extent. This is due to the tartaric acid, which is very soluble in water. The next important thing to find is the method for applying the developer. Having sensitized with the ordinary black print solution and perfectly dried several strips of paper about three inches wide, I applied to each, by means of a glass rod, a solution of tannic acid in water different for each strip. The original tannin solution was made one to eight and was divided into about ten parts; to each of these parts was added one of the following acids: Sulphuric, nitric, muriatic, phosphoric, oxalic, tartaric, citric, boric, acetic, in various proportions. After the application of this second solution the film took a tint varying from gray to black. The sulphuric acid gave the lightest tint. Upon exposing to the light, under a tracing, the various papers, all printed with different lengths of exposure, and after washing in water, they all reproduced the lines of the tracing, but the background was tinted.

The lightest tint, slightly gray, was that of the sulphuric acid paper. Similar experiments made with alkalies instead of acids did not produce any good result. As soon as the solution was applied to the film, this latter turned black. It was evident that sulphuric acid was the best agent to employ. After many trials the following solution was arrived at:

	Parts.
Water	100
Tannic acid	13
Sulphuric acid	5

We have seen that sulphuric acid precipitates tannin from its aqueous solution, but there is a way to prevent this. Dissolve the tannin in six and one-half times its weight of water, and when the liquid is very clear add slowly the sulphuric acid, mixed with the remaining quantity of water. After a small amount has been poured in the bottle containing the tannin solution, a precipitate tends to form, then shake well the bottle until the solution is clear again. Shake this bottle vigorously after each addition until the last drop of acid is added. This solution remains clear and does not form any precipitate for more than forty days.

If good quality paper is sensitized with the solution given in the first paper and is well dried, the above tannin solution can be applied on the surface of the first film. The paper, again dried, will have on its sensitized face, a light gray tint.

An exposure of about four minutes, or the same as the acid developer paper, is necessary. Taken from the frame, the print shows in dark gray lines upon a yellowish ground. The developing is done by immersing the sheet in clean water until the lines are dark blue. It is not possible to obtain absolutely black lines, but with a good tracing very good work may be done. It is preferable, instead of immersing the print immediately in water, to use a hose, and thus send a jet of water against the surface of the paper. This has the effect of detaching more readily the decomposed salts from the film and to activate somewhat the developing. After two or three minutes the print is immersed in water for five or six minutes and then hung up to dry. It is necessary to often renew the water in the bath, because the iron salts washed away are affected by the air and tend to assume a light blue tint, which would be communicated to the prints after about one dozen had been washed in the same bath. This precaution must be taken for all black print processes.

If the iron or sensitizing solution such as advocated is used, no matter how well dried the paper may be before the developing solution is applied, the presence of the tartaric acid in such quantity is bound to render the first solution soluble, and consequently some of the iron salts mix with the tannin, darken the liquid, and, after a while, spoil the developer, i. e., form a precipitate which it is hard to dissolve again. The iron salts, iron perchloride and tersulphate, if mixed with the gum arabic in water, will form an insoluble compound when dry, as we have seen. When only a small quantity of tartaric acid is added, the insolubility remains; consequently, for a certain amount of iron solution, put only one-half the quantity of tartaric acid and put the other half in an equal quantity of the developing solution. It is understood that the paper, in order to be uniformly coated, must be treated by machinery. It would be impossible to coat any large amount by hand, since any irregularity shows on developing.

THE SPINNING, STAMPING, AND WORKING OF ALUMINUM AND BRASS SHEET.

Owing to recent improvements which have been made in the manufacture of aluminum sheet, it is coming very generally into use for certain classes of articles, for the reason that it is not only more easily worked than brass, but also because it does not require as much annealing as brass does, and in many instances aluminum sheet can be spun or stamped into shape by starting with the proper grade of soft sheet; whereas in brass there are many articles that would have to be annealed in the successive operations before they could be spun to these shapes. This is because aluminum is more ductile than brass, and is a saving in favor of aluminum, and unless the successive operations of annealing the brass are carried out perfectly, there will be a greater loss in the brass sheet than there will be in the aluminum sheet. Brass hardens up quicker under the tool than aluminum, and that is why aluminum does not have to be annealed as often as brass.

Then, again, in the manufacture of brass sheet, special sheet that is to be used for drawing or spinning requires the very best grades of zinc; for if there are any impurities in the zinc, it will cause the brass sheet to be very brittle and not work up as readily. The impurity in zinc which has the most deleterious effect is arsenic. While great care has to be exercised, therefore, in the kind of brass sheet which is used where it is necessary to do spinning or stamping, in the case of aluminum sheet where drawing or spinning is to be done it is only a question of the proper amount of annealing before starting to work the sheet. The majority of the aluminum sheet which is being manufactured into various articles is the pure metal, guaranteed to be over 99 per cent. pure.

There are, however, many grades of alloyed sheet which are particularly desirable for special purposes where a harder and stiffer metal is required than can be obtained by the use of pure metal. A discussion of these different grades for specific purposes the writer does not consider advisable to take up here, for there is an endless variety of them, and an attempt at a discussion might mislead users of aluminum sheet because of a supposed similarity of use which really does not exist. For instance, there is a special grade of aluminum sheet made for the manufacture of cartridge shells. The great object to be attained here is to make a sheet which will have a sufficient amount of ductility to enable a shell to be properly drawn, and yet at the same time to have a certain amount of the proper hardening ingredients, so that the firing of the loaded shells will not anneal the metal to such an extent that it will render the shell unfit for reloading.

If a grade of aluminum sheet was described which would draw into these shells, it might ordinarily be supposed that another article approximately the same size and amount of draw would take the same sheet. For the reasons above stated, it can readily be seen that such is not always the case, and therefore when particularly hard sheet for specific purposes is required, it is advisable to leave the selection of the grade and alloy that is to be used to the manufacturer, stating explicitly what is expected of the sheet and leaving it to his experience to supply the proper grade. This can safely be done, for the reason that all aluminum sheet is a certain price, as the total amount of alloying ingredients in but very few cases exceeds two per cent. and the cost of making these alloys, if anything, is more expensive than the cost of the pure metal.

This is owing to the reason that these alloys are made under the influence of the electric current, and great care has to be taken in reducing them from their oxides, or most convenient form in which they are found in nature, and combining them with the aluminum, which is at the same time reduced from its oxide. Whereas in brass sheet the percentage of zinc ranges from 30 per cent. to 35 per cent., which is very much cheaper than copper, and it is for this reason and also for the reason that the best grades of zinc cost about twice as much as the grades used for casting purposes, that the Brass Manufacturers' Association have established a price for brass sheet according to the purpose for which it is to be used.

More or less complaint has been made at different times by the users of aluminum sheet because of its being too soft. This to a certain extent is the purchaser's own fault, for the reason that when a certain quantity of sheet is ordered and it is not specified of any particular grade, or the purpose for which it is intended to be used, pure aluminum sheet is shipped. And it has got to be understood that when no particular grade or alloy is mentioned, the pure metal is what is wanted. If manufacturers of goods in ordering would be a little more explicit and state for what purpose the sheet is intended, manufacturers of the metal would often aid them. Aluminum for spinning should be soft. If not very much spinning is required and it is desired that the article when spun should be particularly stiff, it is advisable to use alloyed sheet. If, however, very much spinning is required, and a not unusual amount of stiffness of the completed article is wanted, it is advisable to use the pure metal.

For the particular reason that it is softer and more ductile, the time required for spinning, and consequently the labor to be employed, is less. This also applies to metal which is to be drawn. In some cases it is advisable to use an alloyed metal, annealing it for

successive operations, rather than use pure metal which could be worked to the finished form without annealing. The latter, however, would not make any article as stiff or as rigid when completed as an article made from the alloyed sheet as previously stated.

In regard to stamping aluminum, generally speaking, a hard sheet should be used; by this is meant either pure sheet rolled hard, or the alloyed sheet rolled hard and not annealed as the final operation, as in former cases for spinning and drawing. If, however, any flanging or working of the metal is to be done, it introduces another question which might change the grade of sheet to be used. This is also true of brass sheet, but sheet which is simply stamped out and has no other work upon it, such as clock frames, can be made of the cheapest grade of brass, which means brass made by the use of a cheap grade of zinc.

As far as the working of aluminum is concerned, it differs from the working of brass only in the form of lubricant used. For spinning and drawing purposes in aluminum, vaseline will be found to give the best results, and not the ordinary soapy mixtures which are used for brass. This to a certain extent is true also of aluminum which is to be stamped, where any lubricant at all is required. In the majority of cases, however, aluminum had best be stamped dry. If, however, it adheres to the dies, or has to go through any dies and the metal is found to stick to the same, if vaseline is used, it will be found in the majority of cases to overcome this difficulty.

In general it is not advisable to solder articles which are manufactured of aluminum. This is one point on which aluminum differs materially from brass—a serious drawback in introducing aluminum in competition with brass. This is for the reason that the question of soldering aluminum is not an easy one, and even when this is accomplished it is more or less uncertain as to how long the solder will hold, for the reason that the basis of most solders for soldering aluminum is block tin and phosphor tin, in proportions of about half and half of each, and these two metals, that is, the tin and aluminum, stand so far apart in the electro-chemical scale that there is a decided current of electricity set up which forms what is known as a galvanic pile, and the effect of this is to oxidize the most positive metal first, which in this case is the aluminum. This oxidation will take place on the surface of aluminum where the solder joins it, and in six or nine months, unless the soldering is done with a great degree of perfection, it will drop off; and it is impossible to judge of any solder without giving it a time test.

The fact that this current is set up by the two metals coming in contact can be demonstrated easily and by a very simple experiment. Take a piece of aluminum and a piece of copper or tin, whichever can be secured most easily, or even silver will do, put the two together so that their surfaces are in contact, allowing the edges of the two to be at the same point and touch them to the tongue, so that the tongue is in contact with both of the different metals at the same time, and there will be a decided taste on the tongue, which in some cases might be imagined to be due to the taste of the metal itself, but if each one is tasted separately it will be found that there is no taste at all, and what is felt is really an electric current set up by the two metals coming in contact with each other.—The Aluminum World.

THE CHIMES OF SAINT-GERMAIN-L'AUXERROIS.

FOR a few years past chimes have again been coming into favor. A number of cities of Belgium and of the north of France have, as we know, orchestras of this kind that date back to the seventeenth or eighteenth century. Several of these, and those none of the worst, were left for some years in a deplorable state. Abbot Van Hoorenbeeck, the benefactor of Sainte-Gertrude of Louvain, was, among our neighbors, the promoter of the great work of restoration undertaken on every side—at Diest, Ostend, Roulers, Audenarde, etc.

In France we are witnesses of the same zeal. There is, however, the difference that since among us the municipalities are essentially laical, the expense attending the installation or restoration of chimes is borne especially by the ecclesiastical authority. The city of Paris, nevertheless, has just made an exception to this rule by voting the funds necessary for the restoration of the chimes of Saint-Germain-l'Auxerrois. It is true that these chimes are a very fine piece of work, that the expense was not very great (scarcely a thousand dollars), and that the municipal architect, M. Gion, fought nobly to obtain authority from our ediles to execute it.

The bells installed in the turret of Saint-Germain-l'Auxerrois are 38 in number and occupy a considerable space. Their total weight is 22,000 pounds. The largest, which weighs 4,400 pounds, gives do. To each note there are four hammers actuated by an independent train of wheels. The large bell alone is destitute of hammers, although, like the others, it has its wheelwork. It consequently serves merely for striking the hours of the clock. The chimes, as a whole, comprise 148 hammers, with 148 traction wires and 152 levers.

The play of the bells is produced automatically or by hand. The automatic playing is effected by a steel cylinder 52 inches in length, 16 in diameter, and 1⅛ inch in thickness, provided with 29,184 apertures arranged upon 228 revolutions of a spiral. It is thrown into gear by the belfry clock twice a day—at 11 and 4 o'clock. The starting gear sets in motion a strong train of wheels (actuated by a weight) which carries along a cylinder studded with pins that correspond to the airs that it is desired to play. These airs are now

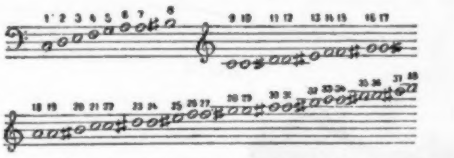


FIG. 1.—NOTES OF THE CHIMES OF SAINT-GERMAIN-L'AUXERROIS.

three in number: "La Marche de Turenne," of Lulli, "Le Tambourin," of Rameau, and the "Vieille Chanson Française." M. Chapuis, the organist of Saint-Roche, was commissioned to arrange this music, which is necessarily somewhat special. Its cadence corresponds to the 76 of the metronome. In values of quavers, the three airs just mentioned represent respectively 320, 224, and 224 units. It would be very easy to change the airs at will by shifting the pins or putting in new ones. Each of the latter is about 2¾ inches in length and is provided with a thread at one end by means of which it is screwed into the cylinder. Each pin in passing trips a lever that corresponds to the note that it is to give. This lever itself throws the wheelwork of its bell into gear, and then one of the cams passes and a blow is struck. We have said that each train of wheels pulls four hammer tails or levers. The cams or tappets of these are arranged upon the two faces of the striking wheel in such a manner that one of the hammers is always ready to strike, two are in a more or less advanced state of preparation, and one is at rest. It is this arrangement that permits the chimes ringer, in fingering the keyboard, to execute passably quick airs.

The accompanying figures, from La Nature, show the general arrangement of the hammer tails, which, along with the traction wires, levers, and other accessories, form a most picturesque group.

The playing by hand is done through the intermedium of a keyboard almost exactly like that of a piano, only a little more force is required to press the keys. The latter are 48 in number. Eight of these correspond to no bell and one actuates the wheelwork of the gravest do, which has no battery of hammers. The chimes ringer can, therefore, use 37 of these keys and play all the airs that they permit of. The same note may be repeated up to five times a minute.

The keys of the keyboard produce upon the starting gear of the wheelwork the same effects as do the pins of the automatic cylinder.

The system, as a whole, occupies a space of no less than 60 feet in height and an octagonal surface of 108 square feet, or, in other words, a space of 700 cubic feet. The weight room is 19 feet in height by 11½ in width, and that of the mechanisms (which is above) 14¾ by 12 feet. Finally, the room for the bells and their batteries, which is away above, is 31 feet in height and 11¾ in width. The cylinders of the bell weights have diameters varying from 10 to 52 inches. Each cylinder, with its wheelwork, accessories, and striking train, constitutes a true clock.

This installation is unique in its way.

The chimes of Saint-Germain were finished in 1878.

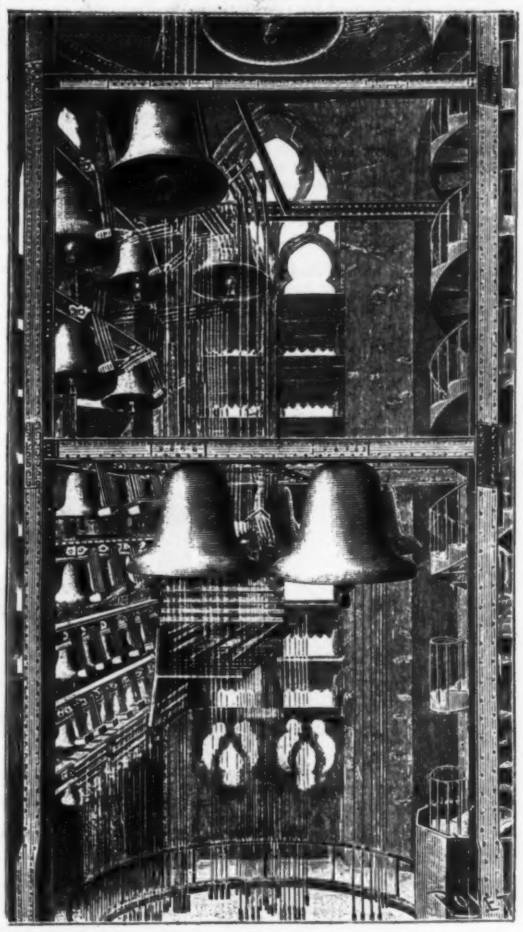


FIG. 3.—BELLS AND BATTERY OF THE CHIMES.

Their construction extended over a period of fifteen years. An inscription upon the large bell informs us that it, as well as its companions, was cast in 1862 by A. Hildebrand, "fondeur de S. M. l'Empereur Napoleon III." The entire mechanism is the work of the clockmaker Collin. Before presenting the final system that was executed, Collin made numerous experiments before a commission appointed to this effect and composed of M. Ballu, the architect, Baron Seguier, Chaix d'Est-Ange, M. Bezozzi, a musician, M. Barker, a manufacturer of organs, and M. Henry Lepaute, a clock manufacturer.

The automatic cylinder, now of steel, was then of wood, and was provided with pins arranged for the following airs: The song of "Cloches de Corneville," played at 8 o'clock in the morning; the ballet of "Si j'etais roi," played at noon; the air of "Carnaval de Venise," at 8 o'clock in the evening; and "Noel" (by Adam), at midnight. The Parisians scarcely had time to appreciate their chimes, for hardly had they been installed when they were abandoned and remained mute for twenty years.

When M. Gion, the successor of Ballu, desired to restore life thereto, it was necessary to proceed to a restoration according to regular form. M. Chateau, who had already restored the astronomical clocks of Rouen and Lyons, was commissioned by the municipal council to execute this work, the reception of which occurred on July 7.

The chimes of Saint-Germain-l'Auxerrois are now in fine shape and ready to charm the visitors to our future exposition. Paris could not really afford to neglect to do what most of the cities possessing chimes are doing on every side.

The apparatus under consideration is the first in which the pins of the cylinder and the keys of the keyboard have had simply to effect a starting instead of directly raising the heavy hammers of the bells. It is the first truly mechanical arrangement of the kind that has ever been constructed.

The following are the approximate weights of the bells according to the number of order and note: 1, do, 4,400 pounds; 2, re, 3,300 pounds; 3, mi, 2,200 pounds; 4, fa, 1,870 pounds; 5, sol, 1,320 pounds; 6, la, 990 pounds; 7, la♯, 770 pounds; 8, si, 715 pounds; 9, do, 550 pounds; 10, do♯, 490 pounds; 11, re, 440 pounds.

The last thirteen notes have the same diameter, and differ in thickness only.

The following are a few of the principal chimes in France; First, the dean, that of Dunkirk, which disputes the honor with Alost of having possessed the first orchestra of bells. The present chimes ringer, M. Pieters, has here 49 bells at his disposal. The largest weighs about 7,700 pounds. Chalons-sur-Marne and Perpignan possess chimes that are quite new, the former of 56 and the latter of 46 bells. Cambrai and Saint-Amand du Nord have each 38 bells, Merville has 39, Saint-Quentin 31, Arras 24, Bonsecours 25, Pontmain

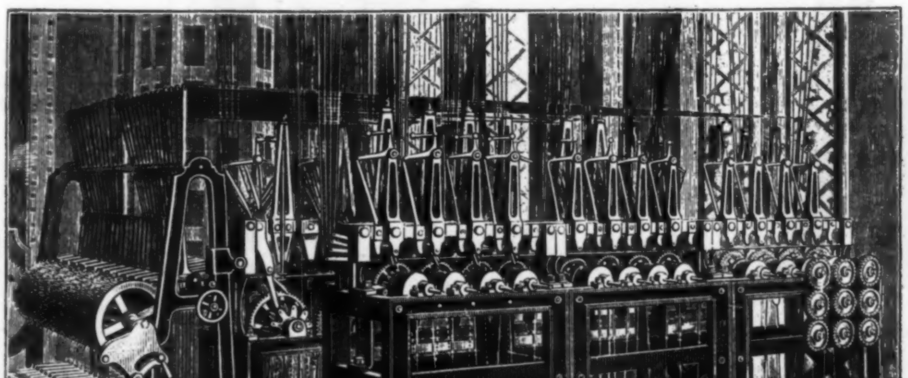


FIG. 2.—KEYBOARD, CYLINDER, AND MECHANISM OF THE CHIMES OF SAINT-GERMAIN-L'AUXERROIS.

25, Notre-Dame de Bugiose 23, and the Basilica of Fourviere 13.

Chimes that are richest in bells are not the ones that possess the greatest weight of sonorous metal. Bells giving grave notes, in fact, present great differences in weight. If, for example, it were desired to add to the chimes of Saint-Germain-l'Auxerrois only the si flat and the la below grave do, which is the principal note of it, such addition would represent 17,600 pounds of bronze—nearly the weight of the chimes as they now exist.

In support of what has just been stated, a typical example is furnished by the famous Westminster chimes, which consist merely of a clock striking train of 5 bells, the largest of which weighs over 30,000 pounds, and the whole 44,000 pounds more than the 56 bells of Chalons-sur-Marne.

In order to give some idea of the value of the chimes under consideration, we may state that M. Collin received $15,990 for the work. As the founder charged nearly the same amount for his part of the work, and as there was furnished with the chimes a clock, a barometer, and a thermometer of the value of about $5,400, it will be seen that the city of Paris spent scarcely less than $40,000 for the entire affair.

THE ZIEGLER-HAGER TACHEOGRAPH.

We illustrate herewith a clever surveying instrument, remarkably simple in theory and manipulation, which has for several years been in use on the Continent, but has not been noticed yet in this country. It is the universal tacheograph of Victor von Ziegler, a well known writer on geodesy, and of C. Hager, scientific instrument maker, of Luxemburg. The instrument, which is constructed in various forms for special purposes, belongs to the class of plane table theodolites. Its chief merits are that horizontal distances and vertical heights are read off at the same time, that there are no calculations, that the instrument checks itself, and that the operations require very little time and skill.

It will be noticed that the view, Fig. 1, and the elevation, Fig. 3, do not agree; the latter refers to an older type, which does not differ in principle, however. The telescope—which lies in two forks and can be completely reversed, if the level should be questioned—turns about the pivot, O (Fig. 3), which, in the new instrument, is the center of a disk provided with arc divisions of ± 30 degrees, and with a vernier. The telescope rests with an agate pan, F, on the knife edge, U, of a vertical steel bolt. This bolt, and the telescope with it, moves up and down when the micrometer screw, T, is turned. Bolt, screw, and telescope are further raised or lowered with the slide, C, when the head, t, is turned. We have thus two movements for the telescope, but the slide, C, takes part in the second movement only, gliding up and down in the standards, R. The right standard is provided with a scale of tangents, a corresponding division on the slide acting as vernier. When we read 12·9, we have to understand that the tangent of the angle of inclination of the telescope is 0·129; we may convince ourselves that this is correct by noting the angle on the disk graduation. The movable micrometer drum bears marks 0, 1, 2, 4, 5, 10; there is a zero mark above fixed to the slide, and, further, a pointer traveling on a vertical plane over an arc (shown in Fig. 2, but not shown in Fig. 3, which has also a different drum), likewise marked 0, 1, 2, 4, 5, 10. This latter addition, the pointer and its arc, have nothing to do with the precise measurement; they are merely intended to indicate at a glance that the drum has been turned the right way. The horizontal distance, h, between the pivot, O, and the vertical bolt, $m\ n$, is the base line of the instrument. The micrometer divisions are such that when the drum is turned down from mark 0 to 1, the telescope will have descended by $\frac{1}{100}$ of the length, h; when turned between 0 and 2, by $\frac{2}{100}$, and by $\frac{5}{100}$ if the marks 5 and 10 are used. When we use the constant 0—1 or 1—2, the distance to be measured is 100 times the vertical scale divisions observed; when we take the constant 2—4, the ratio will be $\frac{2}{100}$; with the constant 5—10, $\frac{5}{100}$. In the last case, therefore, our distance will be 20 times as much as the scale divisions through which we have lowered the telescope. This constant 5—10, or $\frac{1}{20}$, is recommended for short distances.

Supposing we wish to measure the horizontal distance between points x and y (Fig. 4). The tacheograph is placed at x, A is the pivot, corresponding to O in Fig. 3; the staff is placed at y'. This staff is divided downward, and has its zero above. We sight at that zero on the staff, in the direction $A\ v\ p$, read off the tangent 26·4, and turn the micrometer drum from mark O down to 1; the telescope now points, let us say, at staff division 112·5 in the direction $A\ t\ q$. We have finished; but, to check our observation, we at once turn the micrometer further down to mark 2; the cross hairs should now stand $225 = 2 \times 112{\cdot}5$; if not, a slight mistake has been made on the first reading, and we can verify that by turning back, upward, to mark 1. We had 112·5, using first the constant 0—1, and then the constant 1—2; this constant is the $v\ t$ of Fig. 4, equal $\frac{1}{100}$ of h. As now: $v\ t : A\ o = p\ q : A\ B$, we know that the distance $A\ B$ to be measured is $100 \times 112{\cdot}5$. When the staff is divided in centimeters, the distance is 112·5 meters. This distance we prick off on the round table, with the help of the vernier on the alidade. The tangent was 26·4; that means 0·264; the difference in level between A and p is, therefore, $0{\cdot}264 \times 112{\cdot}5$ meters $= 29{\cdot}7$ meters. From this figure we have to subtract the length of the staff; we have also to add the length $A\ x$, that is to say, the height of the tripod; we have then the level difference between x and y.

To go back to the description of the instrument, the whole upper part, standards and alidade, can be turned about the center, a, of the round table on which the drawing paper is spread. When we wish to determine the distance of another object, to the left or right of the first, we turn the alidade, clamp it by the screw, g—there are fine adjustment screws for this horizontal movement—sight, measure, and prick off as before.

Any intermediate points on the diagonals from a can be measured without moving; in this way we settle also the intermediate cross lines. The angles about which we have turned can be read off on the horizontal

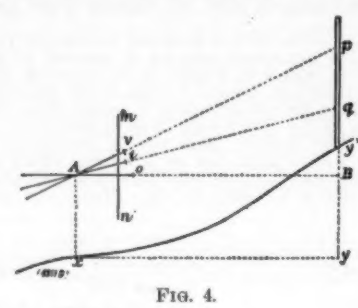


Fig. 4.

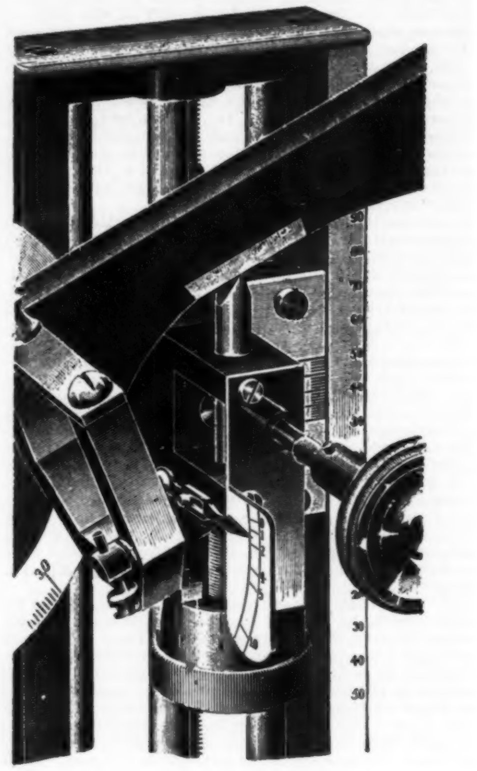


Fig. 2.

Fig. 1.

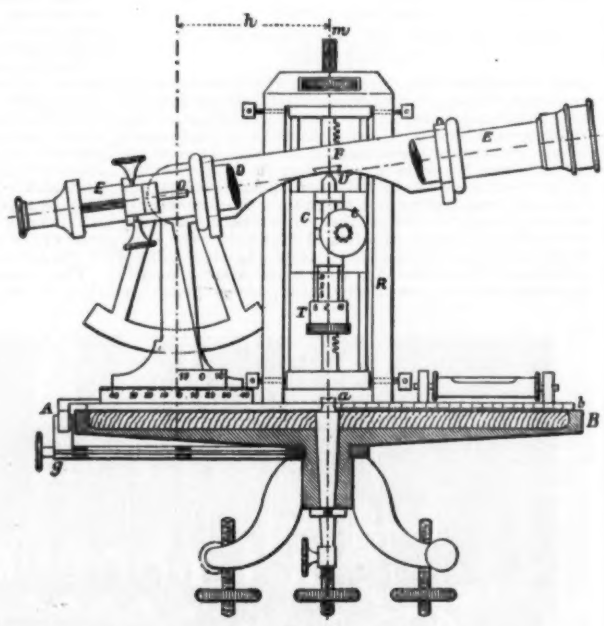


Fig. 3.

THE ZIEGLER-HAGER TACHEOGRAPH.

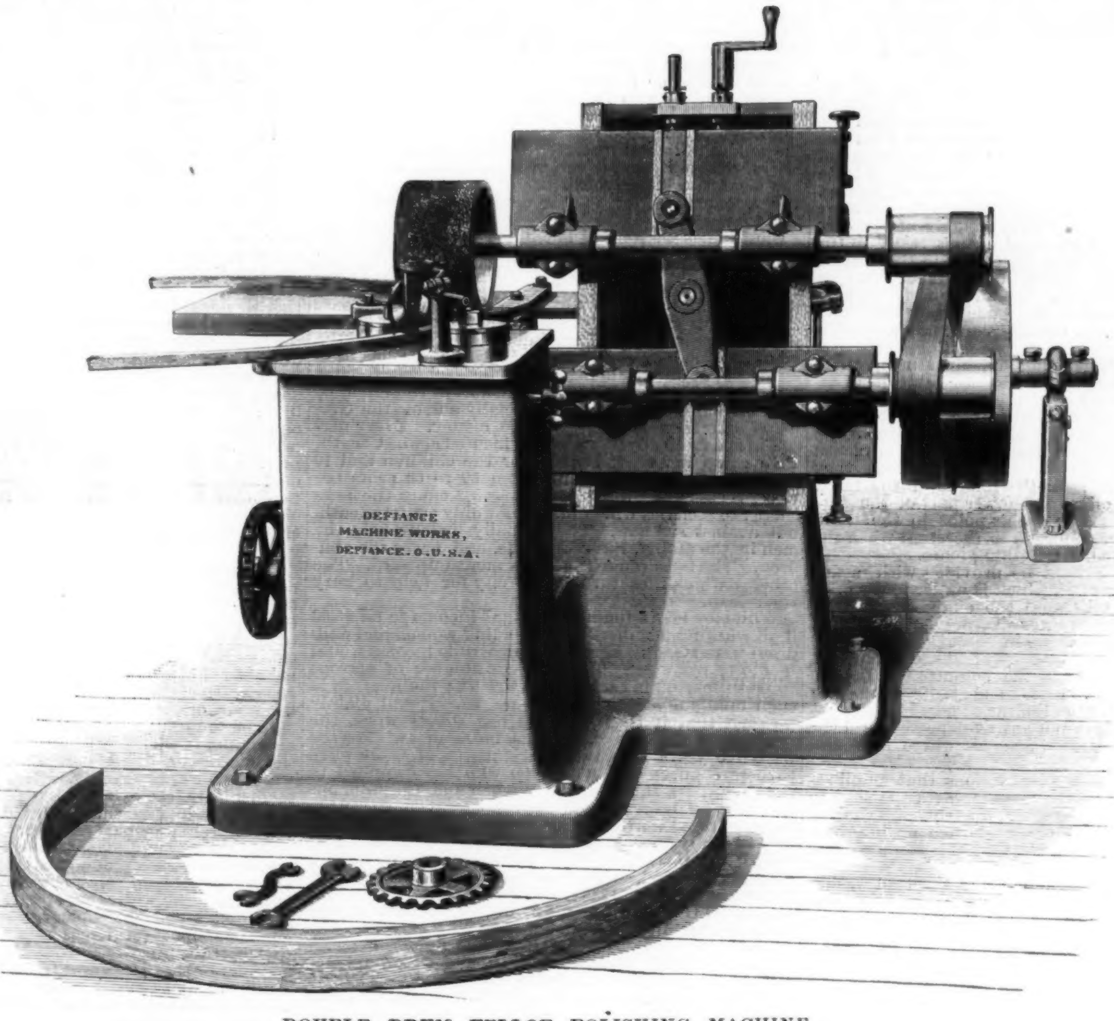
circle. As a rule, this will not be needed, however, for we cannot obtain greater accuracy by reading off angles and calculating than by direct plane table working.

The three leveling screws of the table fit into grooves of the tripod stand, which is of the now usual construction, both firm and light, and provided with a screw and a strong spiral spring by which means the table is secured to the tripod. The instrument is neatly and carefully finished. There appear to be no delicate parts likely to get out of order. If the steel edge should show traces of wear after long and hard usage, which does not look likely, any slight mistake arising from that source could easily be ascertained and allowed for. Mr. Hager's instruments have found great favor with surveyors and mining engineers in Luxemburg, France, and Germany, as being both accurate and convenient, and a tacheograph with an extended table has been used, for instance, this autumn by the Luxemburg State Railway Department. We should mention his staff. It is made of triangular section and is hinged in the middle so that it can be folded up to form a prismatic bar; the centimeter divisions will then be on the inside faces, and thus not exposed to any wear. We are indebted to London Engineering for the engravings and description.

AN IMPROVED FELLOE POLISHING MACHINE.

THE Defiance Machine Works, of Defiance, Ohio, have designed a new wheel-rim polishing machine, which is so arranged that it can be readily adjusted to polish felloes of different sizes.

The machine has a frame provided with an upward extension, the former being constructed to receive the rim supporting and guiding devices and the latter being adapted to support the polishing mechanism. The upward extension is made with flanges constituting guides for saddles disposed one above the other. Against each saddle a guide-plate is located, which, with the parts that it carries, may be adjusted to different angles. To receive dovetailed enlargements or guides on slide plates, the guide-plates are recessed in one face. The ends of the slide-plate project beyond the ends of the guide-plate and serve to protect the sliding contacts or guideways from dust. The slide plates have bosses or enlargements which constitute bearings for spindles. Each spindle carries at its ends a pulley and a drum, the latter being covered with sandpaper. The spindles, drums, and pulleys can be adjusted up or down to polish wheel-rims of different thicknesses by means of screws passing through lugs on the saddles. In order that the sandpaper drums may operate uniformly, it is necessary to impart to them a reciprocating motion in addition to the rotary motion given by the straps shown in the engraving. This reciprocating motion is obtained by placing in a transverse groove on the slide-plates, idlers carried by a cross-head. This cross-head, as indicated in the illustration, is secured to one end of a transverse shaft, to the other end of which a lever is secured. With the lever a crank-pin is connected by means of a pitman and a universal joint, the crank-pin being in turn carried by a crank-wheel secured to a shaft in the lower part of the framework. With this mechanism a slow reciprocating motion is obtained. In order to feed the rim accurately, while it passes over its table between the polishing drums, a mechanism is employed consisting of hinged arms in which spindles are mounted. Feed-rollers are mounted on the spindles and engage the rim. Yielding devices bearing on the hinged arms coact with the latter to enable the feed-rollers to receive rims of different thicknesses. Rotary motion is transmitted to the feed-rollers by gearing located in the frame.



DOUBLE DRUM FELLOE POLISHING MACHINE.

HOW TO READ GAGES.*

PRESSURE GAGES—GLASS GAGES—ASCERTAIN CONTENTS OF TANK—HOW TROUBLE WAS LOCATED.

By ALFRED SIEBERT.

PRESSURE GAGES.—Everybody has noticed the oscillations of the hands of the gages, and most people believe that these oscillations are caused by the suction of the compressor or pump; if this were really so, it would indicate that the pipe connections and valves were too small. In fact, however, the above will affect the gage so little that the eye would hardly notice it. There is a reason for this oscillation which will appear from the following deductions:

In the first case the compressor or pump does not have to induce the gas to flow, but the gas is forced by the rapid evaporation taking place in the evaporating coils; while the gas is so pushed, still it cannot move before the suction valve is opened, and therefore the suction pressure will be a little higher when the valve is closed than when same is open, depending on the amount of space in the evaporating coils and on the space in the pipe connections, furthermore, on the length of time during which the valve is closed.

However, the effect of the above will in most cases hardly be noticeable, but there is another cause for this oscillation which is easy to understand and which is the same as takes place in water pipes. Everybody knows that when a valve, located in a water pipe carrying water under considerable pressure, is quickly closed there is a loud noise and the pipe shakes, caused by the sudden stop of the rapidly flowing water, or when the so-called hydraulic ram is formed.

Now when the suction valve in a compressor or pump suddenly closes the same action takes place, the gas stopped suddenly in its flow recoils, and the force so exerted increases the pressure of the gas, causing the hand of the gage to make a violent motion. It is therefore evident that the lowest position of the hand is the proper reading.

It is also said that this oscillation is caused by the lap of the valve, but this can have no influence. The reduction of pressure necessary to open the valves against the pressure prevailing in the evaporating coils takes place in the compressor during the time the valve is closed, and consequently the connection between compressor and valve is broken; furthermore, the piston travels at times so slowly, and the space to be filled with new gas (which has even a little higher pressure than the regular suction pressure) is so small, that no effect of this reduction of the pressure inside the compressor could be noticed.

The same is the case with the discharge gage. While the discharge valve is closed there is a flow of gas to the condenser or cooler caused by the condensation of the gas in the condenser or the cooling of the gas in case of air compression machines in the cooler. When now the discharge valve opens, forcing quite a volume of gas into the pipes, which is in the beginning under a much higher pressure than that prevailing in the condenser, owing to the lap of the valve as explained before, the gage hand will certainly be violently moved and then settle back; therefore, again the lower position of the hand is the correct discharge or condensing pressure. That the above is in practice correct can be and has been proved by the writer by comparing carefully gages and indicator cards.

Glass Gages.—It is an easy matter to read a glass gage when there is only one liquid present and when same is colored, but when the liquid is colorless, like water and ammonia, it is sometimes difficult to determine whether the glass is full or empty; there is no trouble of course when the level can be seen.

The ordinary way of ascertaining whether there is liquid in the gage or not is, bear in mind the fact, that if the gage is empty, there will appear in the glass a streak of different color from the rest of the glass, which of course is nothing but the opening of the tube, and the change of color is caused by the reflection of the light; this test is, however, not always reliable, owing to discolored glass.

A much better way is to place a black painted lead pencil or small spike right behind the gage at an angle of 45° to the axis of the gage, and, if possible, so that the light is behind the pencil. If then the pencil shows unbroken, running in a straight line through the glass, the gage is full; if, however, the gage is empty, the pencil will show another angle in the glass just as if it were broken.

If, however, two liquids are present, then the above method will tell only whether the gage is full or empty; furthermore, it is easy to see which of the two liquids is in the glass if they are of different color, as, for instance, oil and liquid ammonia; but now the question arises, Can the gage be trusted in regard to this? If the liquids were oil and water at ordinary temperatures the gage would only show water as long as the opening of the lower gage cock is still covered by water.

The gage does not show the true height in the tank to which it is attached, because the weight of a column of the liquid or the two liquids in the tank per square inch must be the same as a column of the liquid or mixture of liquids in the gage per square inch. Taking the case of oil and water being in the tank, but only water in the gage, we see readily that the level in the gage does not correspond with the level in the tank, as a mixture of oil and water is of course lighter than water only. In the latter case the difference in height is not material, because the difference in weight of the two fluids is not very great.

In the case of ammonia the difference is greater. Liquid ammonia at ordinary pressure has a specific gravity of 0·6, while ammonia oil has a specific gravity of about 0·9, which means that a column of oil in order to counterbalance a column of liquid ammonia must be 50 per cent. higher. In order now to ascertain the contents of the tank, which can either be done by test cocks or gages (test cocks will hardly be used where

* Ice and Refrigeration.

liquid ammonia is present), we must consider what are the conditions of both the gage and the tank. If we consider, first—

The Oil Receiver.—We find that the tank is always warmer than the gage, owing to the heat imparted to the gas by the compression, while the gage will have the temperature of the surrounding air. It is therefore evident that as long as the compressor does not discharge liquid ammonia instead of gas (which, of course, is a condition which should never exist), no liquid ammonia can be in the tank, and still the gage shows liquid. The reason for this phenomenon is that the gage acts as condenser; the hot gas entering the gage at the upper inlet is cooled by the glass and finally condensed and can be seen running down inside the walls of the tube in drops. Now since liquid ammonia is so much lighter than oil, it is evident that it must float on top of it, but since, as explained before, the liquid column in the tank and in the gage must balance, it is evident that finally all the oil must be pushed out of the gage, while only oil is in the tank.

This means, therefore, when a gage shows liquid while the tank is much warmer than the liquid returning from the condenser, that the oil in the tank stands about one-third lower than the gage indicates. In some makes of refrigerating machines means are provided to blow out the contents of the gage in a drip tank; in this case, of course, when the gage has been emptied and the gage cocks quickly opened again, the gage will show only oil, and the heights of the column in the gage will be the same as in the tank.

The Liquid Receiver.—We find here different conditions; in summer the liquid will be cooler than the air surrounding tank and gage, and therefore gas bubbles will be noticed arising in the gage, indicating that a small quantity of liquid in the tank evaporates. If this takes place, it is of course a sure sign that liquid is in the gage, as otherwise the gas bubbles would not be visible.

If there is only liquid in the tank, the height of the liquid in the gage gives, then, accurately the height of the liquid in the tank; in winter, however, when the air surrounding the tank and gage is cooler than the liquid, no bubbles will be seen, but on the other hand little drops of liquid running down the inside of the tube, since the tube acts now again as condenser. When now oil and liquid ammonia are in the tank, we cannot judge from the respective heights of the two liquids in the gage how much of each is really in the tank; we can only know that since oil is in the bottom of the gage, there must be oil in the tank, but how much cannot be ascertained. We know, however, that when drawing off the oil, if the same disappears from the gage, the lower gage opening is not covered with oil.

Some makers of refrigerating machines using oil in quantities must of course provide better means of ascertaining how much oil is in the tank; at least they must provide means to show when too much oil is in the liquid receiver. Since in this case the orifice of the pipe conveying the liquid from the tank is placed about twelve inches above the middle of the tank, they place an extra gage inlet in the middle of the tank. This will admit the oil to the lower part of the gage whenever the oil has risen to this point in the tank. This gives the engineer a means to ascertain when the danger point is reached, but nothing more.

Glass gages should always be provided with means to blow them out in a tank which is under lower pressure than the liquid, because the engineer can then clean his gage at frequent intervals, preventing the oil from closing up the opening in the gage when gumming and catching small particles of waste. It affords also a feeling of security to the engineer, as he can judge a good deal what he has in his tank, how much of it, and whether his gage is clear or not.

Sometimes a gage does not act as expected, and the writer will give here a few instances where he found the trouble:

Knowing from previous observations that an oil receiver had too much oil, the writer was astonished to see, when opening the gage cocks, that the gage showed no oil. Blowing out the gage showed no improvement; so the writer concluded that the stoppage was such that the pressure could not remove it. When the gage was removed, it was found that the lead washer forming the joint between gage and gage cock was squeezed together, so as to prevent the liquid from entering the gage.

Another time, when the writer also knew that the tank had considerable oil, he found no signs of it in the gage, but since this tank was connected above and below with another tank on same level, therefore thoroughly equalized, and the other tank's gage showed oil, he concluded that a stoppage existed somewhere.

The gage was blown out—no result; then the gage was taken out and examined, and finally a bung like those used to protect ammonia cocks during shipping was found; this bung, closing the opening of the lower gage cock, had prevented the oil from entering the gage from the tank, while when the oil was pumped in the tank, same not being under pressure (there being no pressure in the gage), the bung had acted as check valve, lifting with every stroke of the pump and allowing the oil to enter gage and tank.

Another time the writer knew again that a large quantity of oil was in the tank, and yet the gage showed none; blowing out was resorted to, but without result, and the writer ordered, therefore, the gage taken out, but found that it took an extraordinary time for the gas which was in the gage to escape; so he finally had the gage made tight again, and proceeded to examine the cocks.

He found now that the lever of the upper gage cock had been reversed, so that only one gage cock was open at a time; the lower handle was correctly set, so that when the gage was apparently open, only the lower gage cock was in communication with the tank. Since the gas could not escape and make room for the oil, and the temperature in the engine house was such that the gas could not condense, the oil could not enter the gage.

English capitalists are already preparing to buy the railroad which Sir Herbert Kitchener has built in the wake of his army practically as far as Omdurman. The gage is the same as that of the line from Cape Town to Buluwayo, which before long will be extended to Lake Tanganyika.

LIVING CONDITIONS OF THE POOR.*

My studies have been made almost entirely on the east side, between Fourteenth and Bayard Streets, Elizabeth Street and the East River. This section of the city, notorious for its overcrowded condition, contains representatives from all over the world. Indeed, in this region, in half an hour's walk, one will find signs in the Hebrew, Greek, German, Russian, Hungarian, and Italian languages more frequently than in the English, and in some parts of this district one may spend a day and not hear one word of English; a section containing very ignorant and very poor people, many sweatshops, many beer saloons, many "Raines law hotels." Each nationality is as distinct as in its own native home over the sea. Each requires to be studied entirely apart from the others. The greatest problem which presents itself is how to make this most interesting mass of humanity good American citizens, with a strong civic patriotism. That they can become good Americans, I have not the shadow of a doubt.

How do these people exist, and under what circumstances? What is their daily life? The most important item in their life is work, skilled or unskilled, regular or irregular. As to the expenses of an ordinary family (among the families treated at their homes for a variety of diseases in 1891), we found that the average income was $5.99 per week (this never steady); the average rent $8.62 per month, and the average family to be supported to consist of four. In 1897 I found the average income (still irregular) to be $5.23 per week, and the average rent $9.75 per month. The rent, therefore, is the largest single expenditure.

Food comes next. The amount expended is very uncertain and an estimate is very difficult to secure. The people do not keep any accounts and cannot tell themselves. I cannot state with any degree of precision the amount of money expended for food. It has been variously stated at from 9 to 11 cents per day, but it is almost impossible accurately to estimate this. I have known families who for weeks have existed on an expenditure of 5 cents per day for food. The amount and character of the food varies with the nationality and the amount of total income. Women (among the Hebrews) tell me that they can give a morning and evening meal, the latter consisting of soup, bread, coffee, and a vegetable, for $3 per month per person, and make money.

Clothing is an item of much less importance in the cost of living than is food. A woman can buy an entire new suit of clothing, from hat to shoes, for $5. Many never wear a new pair of shoes, but buy second hand shoes, which, for a woman, not infrequently will last three or four months. As with food, it is almost impossible to ascertain with any degree of accuracy the amount of money expended for clothing. It has been estimated at about $10 per annum for each adult. But I think that it frequently falls far short of this amount.

Another item of expense, especially among the Germans and Irish, is the insurance money. Every person in the family over one year is insured against death. Five cents per week is paid for the children and 10 cents for the adults. Thus from 50 to 60 cents per week is expended for this purpose. Among the Jews there are societies which insure not only against death, but against sickness. They usually include only the men in the family, rarely the wife, and never the children. The dues range from $1 a month upward. The other nationalities turn to the city for help to bury their dead.

While for 1897 I found the actual income to be $5.23 if all working members (not including women and children) were steadily at work, the possible income would be $13.42 per week. The average number of persons to be supported in each family was 5·6; the average in each family under fourteen years, 2·7. It will plainly be seen that if these families had steady work, the problem of the poor would not be as great. For the past five years I have taken statistics of 12,519 wage earners connected with families who have applied to the New York Infirmary for Women and Children for free medical treatment at their homes. Of the 12,519 persons, 2,930 worked regularly throughout the year, or with only an occasional idle week. Of these, 1,564 were skilled workers. The normal condition of this class is very good. The position of the unskilled laborer is most serious. It is he who is most frequently idle, and often through no fault of his own. Each laborer believes that fifty men are ready to take his place if he falls out.

The first and perhaps greatest evil which directly follows is that this uncertainty of keeping "a steady job" forces the women and children to work. If there are children old enough to work, they begin before the women do. For the past five years I have found, by our statistics, that in three-fourths of the families visited the women assist in the support of the family (by working for money). This number does not include those who take boarders. Sewing in some form is the principal occupation. We have found that one-sixth of the families had incomes increased by the work of children under fourteen years of age, while, in a little less than one-third of the families, persons between fourteen and eighteen years were working. The children work in stores, run errands, sell newspapers, peddle, and, wherever a woman is working at home, the child helps at that work. Among the Italians, all the buttons are sewed on the trousers by children. Both boys and girls of five and six years can do this work as well as their elders. If this meant only an hour or two after school, no harm would be done, but when the time is extended, at times indefinitely, and the children not allowed to attend school or play in the open air, even of the streets, their health suffers, and they are denied their right to an education.

Overcrowding is a direct result of the small or irregular earnings of the man. When the rent for one month exceeds the average weekly earnings, the family is forced to other measures to pay the rent. Thus, one of two things is done—either they take lodgers or boarders or two or more families occupy an apartment intended for one family. But even when neither lodgers, boarders, nor two families are found, the overcrowding is a serious question. Among 726 families, 505 lived in two rooms only, 41 families in one room, and 144 families had three rooms. One can hardly realize what this means for a family unless a night visit is made. Last year I found 3,472 persons occupying 1,892 rooms; in 1896, 5,072 in 2,703 rooms. Recently, in a similar apartment, where men, women, and children were finishing trousers, we found three families; one lived in the bedroom, one in the kitchen, and the other in the front room. A fourth family came to join the family in the front room on the last day of my visits to the child sick with diphtheria. Such cases are more numerous than the average citizen would think possible.

What can be done? I know of no way to increase the man's wages when all that he can sell his labor for is $1.25 to $2 per day. Some think that if the women and children would not work, the wages would go up. Very likely, but what man would sit two hours and finish a pair of trousers for 2 cents? If there is a demand for only a certain number of men to work, only that number can be employed. Women and children do not compete with the day laborer; they do compete with them in the sweatshop, but there they are much more apt to receive equal pay for equal work. The strict enforcement of the factory law, compulsory education for children under fourteen years, the extension of the mercantile law to all children who work for money, and its strict enforcement to the letter, would obliterate tenement-house work and child labor, and would force those women who must add to the support of the family (and there are many) into factories, where their hours could be more easily regulated. It is obvious that a woman cannot work from 2 or 3 A. M. until 11 P. M. without injury to her health. Neither can she attend properly to her household duties.

What can be done by the municipality toward providing better living accommodations is well shown by the magnificent results secured by foreign cities. Glasgow was the first to begin the movement, and has erected seven large lodging houses, with accommodations for 2,000 persons, separate houses being provided for men and women. Other cities in England, Scotland, and Ireland have adopted similar methods with most beneficial results, and have enacted more stringent by-laws and regulations regarding the construction of houses, the number of windows in the dwelling, and the amount of air space for each inhabitant. Inspectors have been provided to visit the dwellings and see that these regulations are enforced. The result is partially seen in the death rate for England, which fell from 22·5 per 1,000 persons in the decade from 1861 to 1870 to about 19 in the period from 1891 to 1895. Not only has the death rate decreased, but there has been a tremendous decrease in the amount of sickness and a marked increase in the duration of life and physical strength and energy of the people. If New York authorities could be induced to build a block of tenements, for instance, on Elizabeth Street, between Houston and Prince Streets, they would be immediately filled by a mass of people who, at the present moment, are a constant menace to the health of the city. The death rate of New York city even now is entirely too high. In 1897, the number of deaths of children under one year was 10,016. The number of deaths in tenements in 1897 was 23,460; in institutions, 10,568; in private families, 4,829; and a large number of the deaths in institutions are of people whose homes are in tenement houses. There is no reason why New York city would not make as good a landlord as the model city of Glasgow.

*Dr. A. S. Daniel, in Municipal Affairs, New York. Condensed for Public Opinion.

Aluminum as a Reducing Agent.—The use of aluminum for obtaining very high temperatures as proposed by Mr. Hans Goldschmidt, in his paper read before the Electro-Chemical Society, at Leipsic, would appear to open up a very interesting new line of research. In this way it is possible to attain temperatures approaching that of the electric furnace without incurring the comparatively large initial outlay necessary to establish and work this latter. The basis of the new method is to be found in the fact that if finely divided metallic aluminum is mixed with certain metallic oxides and the mixture heated, a very violent reaction ensues in which the whole mass is raised to an extremely high temperature, the oxide being reduced in the process. Other experimenters have worked on similar lines before Mr. Goldschmidt, but difficulties always arose from the great, almost explosive, violence of the reaction. It has, however, been found that if the mixture is heated locally, in place of being heated as a whole in a crucible, as in the earlier experiments, the reaction takes place in a much less violent fashion. By heating one particular spot the reaction is started there only, and then spreads progressively and quietly through the remainder of the mixture. In certain cases, however, it is difficult to start the reaction this way; as, for example, if the oxide used is that of chromium. In such cases Mr. Goldschmidt makes use of an "igniting ball," composed of a mixture of aluminum and some easily reducible oxide. This is placed on the top of the main charge, and serves to start the reaction of the latter. The temperature attained can be regulated by adding to the original mixture some inert substance, such as sand, etc. The method can be used for other purposes, as well as for the reduction of refractory metals. Thus a 7 pound steel bar embedded in a mixture of oxide of iron and aluminum was raised to a white heat on starting the reaction. Again, two 1 inch iron pipes were brazed together by surrounding the joint first with the spelter and then outside of that with the aluminum mixture. On igniting the latter the solder was melted, and the joint made. The cost of the operation was about four cents. The most remarkable results have, however, been obtained in the reduction of refractory oxides, as much as 55 pounds of metallic chromium being obtained at a single operation.

The highest chimney in America is at Denver, Col. It belongs to the Omaha and Grant Smelting Works, and serves to carry away the poisonous fumes and gases generated in the process of smelting precious ores. The chimney has the following dimensions: Height above the stone table at ground, 352 feet 7 inches; size at base, 33 feet square; size at throat, 20 feet in diameter; thickness of outer shell at base, 48½ inches; at top, 13 inches; thickness of core at base, 26 inches; at top, 9 inches; diameter flue, 16 feet; foundation, 56 feet square by 16 feet deep. There are at least four chimneys in the world higher than this. One is at Hutte, Saxony, 460 feet; two at Glasgow, 454 feet and 435 feet; and one at Bolton, England, 367½ feet.

ENGINEERING NOTES.

The effect of vestibules in reducing the damage to cars in wrecks was strikingly illustrated by a rear end collision on the Lake Shore August 17, in which the "Limited" ran into six ice cars that were left standing on the main track near La Porte, Ind. The cars of the passenger train had wide vestibules, with the exception of the front end of the buffet car, next to the engine, and this was the only platform injured. None of the other cars was injured and no one was killed, which must be credited to the vestibules.

A recent drilling contest among miners at Glenville, Colorado, showed some remarkable work in hard granite, says The Engineering and Mining Journal. Eight teams took part, and the results were as follows, giving the depth of the hole drilled in 15 minutes: Pettis and Houston, of Aspen, $24\frac{5}{16}$ inches; McBain and Crawford, of Goldfield, $34\frac{15}{16}$ inches; Treweek and Treweek, of Hilltop, $35\frac{1}{8}$ inches; Edmond and McGinnis, of Telluride, $36\frac{1}{4}$ inches; Lyons and McCullough, of Altman, $35\frac{15}{16}$ inches; Huppe and Lindgren, of Ouray, $40\frac{1}{8}$ inches; O'Neill and Burns, of Leadville, $40\frac{1}{8}$ inches; McKenzie, of Leadville, and Lamb, of Victor, $40\frac{15}{16}$ inches. It is claimed that this last has never been exceeded in any similar contest.

The International Society for the testing of materials has practically doubled in membership since the Stockholm Congress of 1897. According to the official list of members lately sent out, the membership in the several countries is as follows: Argentine Republic, 1; Australasia, 1; Belgium, 18; Chile, 1; Denmark, 39; Germany, 387; England, 83; France, 66; Holland, 48; Italy, 35; Japan, 1; Luxemburg, 5; Norway, 42; Austria-Hungary, 111; Hungary, 47; Portugal, 8; Roumania, 20; Russia, 315; Sweden, 68; Switzerland, 83; Servia, 5; Spain, 36; United States of America, 68. The total membership is 1,528. This society has for its purpose the unification of methods of testing materials used in construction with the view of ascertaining their true technical properties and of improving methods of testing. The present president of the society is L. V. Tetmajer, of Zurich, and American engineers desiring further information concerning its objects should address Mr. Gus. C. Henning, consulting engineer, 220 Broadway, New York city. The annual dues are $1, or 5 francs.

Torpedo boat and destroyer awards were made as follows on September 23, by the Navy Department, says Engineering News:

No. Boats.	Contractor.	Class.	Plan.	Price for Each.
3	Neafie & Levy, Philadelphia	D.*	D.§	$283,000
2	Trigg Company, Richmond, Va.	"	"	260,000
2	Harlan & Hollingsworth, Wilmington	"	B.‡	291,000
2	F. C. Wellington, Weymouth, Mass.	"	"	281,000
3	Union Iron Works, San Francisco	"	D.§	285,000
1	Gas Engine and Power Company, Morris Heights	"	..	Not stld.
3	Maryland Steel Company, Baltimore, Md.	"	B.‡	286,000
1	Lewis Nixon, Elizabethport, N. J.	T.†	"	161,000
2	Bath Iron Works, Bath, Me.	"	"	161,000
2	Lawley & Sons, Boston, Mass.	"	D.§	159,400
2	Lewis Nixon, Elizabethport, N. J.	"	B.‡	165,000
3	Trigg Company, Richmond, Va.	"	D.§	129,750
1	Columbia Iron Works, Baltimore, Md.	"	"	168,000
1	Gas Engine and Power Company, Morris Heights	"	..	Not stld.

* Destroyers. † Torpedo boats. § Department. ‡ Bidder.

In 1894 the municipality of Paris, which had repeatedly been occupied with the question of smoke prevention, appointed a commission for inviting competitive tests and reporting upon them. The report has been drawn up by Hirsch, and an interesting résumé of it is given in the Génie Civil. Plenty of apparatus were submitted, but only 10 out of 110 were put to actual tests, all under the same conditions with the same boiler, the fuel being Anzin briquettes. The tests may be characterized as ordinary boiler trials, with particular regard to the generation of smoke. The town granted funds to pay for the fuel and the attendants and staff; the other expenses fell to the respective firms. As may be expected, the results varied much. The apparatus which secured the first prize was superior to all others in smoke consumption, but was also expensive and cumbersome. As we cannot enter into particulars (which our readers will find in the journal quoted), we prefer not to mention names. On the whole, it results once more that smoke consumption and economy do not always go together, and that smoke consumption can be secured only by strict enforcement of the regulations. Gas coke does not produce any smoke, but for the manufacturer the smoke question is not of first importance.

On the Marne-Saône Canal, now being completed, there is one reach of 3 kilom. length with a gradient of 41 meters, i. e., almost 1·5 per cent. The Minister for Public Works decided that this rise should be overcome either by hydraulic lifts, not more than four in number, or by means of locks, and invited tenders from French or foreign engineers. In 1893, already the first prize of 20,000 francs was accorded to James and Alexander Leslie, who proposed eight locks, each with a rise of 5·125 meters, and a year later a second prize of 10,000 francs was given to the Fives-Lille Company, who submitted a similar project. These locks have been adopted. Last year the government arranged for the publication in extenso of the thirteen other projects with complete calculations. These papers fill three volumes, each of more than 800 pages. The volumes form a very important contribution to this branch of literature, and the Nouvelles Annales de la Construction are doing good work by publishing an exhaustive summary of the various projects, leaving out theoretical calculations and matters of purely local interest. The first of that series of articles appeared in the May issue of the journal, and is illustrated by a number of plates. Conspicuous among the projects are the proposals of hydraulic or floating lifts. Apart from the Fives-Lille Company, all the engineers suggested balance compensators, chains, etc., for the bridges and troughs raised by means of hydraulic rams. None of the projects were distinguished by novel principles, but it is not often that so detailed information is offered.

ELECTRICAL NOTES.

The Times says that Chevalier Marconi has fitted his wireless telegraphic apparatus on the top of a pole at Osborne House and at the masthead of the royal yacht Osborne. By means of this apparatus several messages were recently conveyed between the Queen and the Prince of Wales.

The Russian War Department is conducting a series of experiments with searchlights mounted in captive balloons. The current is supplied through the cable holding the balloon to the earth. Searchlights up to 5,000 candle power have been used, and these illuminate an area of 500 yards in diameter when at an altitude of 600 yards.

A communication has been made to the Paris Academy of Sciences by M. E. Branly on the electrical resistance at the contact of two disks of the same metal. The author found that two smooth plane disks of zinc or copper, when pressed together, offer practically no resistance to an electric current under any circumstances. In the case of aluminum, iron, and bismuth, however, the resistance, although small when the disks are simply pressed together, is greatly increased when they are forcibly brought together by falling from a height. The author is unable to offer any explanation of these phenomena.

"**Mr. Hillis**, of the firm of Bagnall Hillis, of Yokohama, Japan, whose firm has a branch at Manila, has been interviewed as to the electrical possibilities of the Philippine Islands," says Industries and Iron. "He says that the commercial possibilities and native resources of the islands are almost unbounded. His firm has installed a central electric lighting station in Manila which supplies current for 12,000 incandescent and 260 arc lamps. There are about 720 miles of telegraph in the islands, and 70 miles of steam railways. Manila has also a telephone system. The conductors are all overhead lines carried on poles or porcelain insulators."

The Chicago and Milwaukee Electric Railway Company, which now connects Evanston and Waukegan, is, says The Street Railway Journal, being completed, and will soon be in operation. It will be about 40 miles in length, and will connect 15 towns, those of the most importance being Evanston, Highland Park, Fort Sheridan, Lake Forest, and Waukegan. The power station is at Fort Sheridan, on the line of the Chicago and Northwestern Railroad. The company proposes to use the three-phase system of transmission, establishing subtransformer stations at different points on the line. The road extends along the west shore of Lake Michigan, a well populated section of the country, which contains the residences of many wealthy families. The road will carry a large pleasure traffic, although the business travel will be also quite an item, it is thought. F. O. Rusling, formerly manager of the Rochester Railroad Company, has recently been appointed general manager of this road.

Schuckert & Co., of Nürnberg, Germany, manufacturers of electrical machinery, report that they have sold electrical machinery aggregating 20,500 horse power to the following companies: Ready to operate in the summer of 1899: Elektrizitätswerk Lonza in Gampel (Wallis), 2,500 horse power. Ready to operate in the winter of 1898–99: Elektrizitätswerk Lonza in Gampel, high voltage, 2,500 horse power; Actieselskabet Hafslund, near Sarpsborg, Norway, 5,000 horse power; Bosniche Elektrizitäts-Aktiengesellschaft, Vienna—works at Iajce, Bosnia—8,000 horse power. Ready to operate in the spring of 1899: Société Espagnole des carbures métalliques (Bullier's patent)—works in Berga, Catalonia—2,500 horse power. The annual production of these works together will be about 20,000,000 kilogrammes of carbide, or 22,000 short tons. The Aluminum-Industrie-Actien-Gesellschaft Neuhausen, at Scheffhausen, are about putting up a new works at Lend-Gastein, of about 7,500 horse power.—Progressive Age.

By the beginning of next year the whole of the Vatican will be lighted for the first time by electricity, which will have the effect of revealing numerous treasures of art and archæology hitherto almost hidden from public view by deficiency of light. This innovation is due to the initiative of Leo XIII., the most progressive and up-to-date of all the pontiffs who have ever filled the chair of St. Peter. The pope is taking a very active interest in the preparations which are being made in connection with the installation of the necessary plant, and it is at his suggestion that the beautiful Aquilone waterfall or cascade in the Vatican grounds is to be utilized for the purpose of providing motive power to the dynamos. The water of this cascade is brought to the Vatican by means of an aqueduct, from the lake of Bracciano, situated at a distance of some twenty-five miles from Rome. It is proposed to eventually extend the electric light to the Basilica of St. Peter, both for interior and exterior illumination.

The smallest electric motor in the world has been built by D. Goodin, of McKinney, Texas, says The New York Herald. The motor is so small that it does not cover a silver dime, and weighs only $\frac{1}{16}$ ounce. The armature is about the size of a small slate pencil. The front of the motor is of gold, highly polished, and the commutator segments are also of the same metal, so that, viewed from a little distance, the scarf pin has the appearance of a very valuable and rather curiously designed pin. It is only when standing near to Goodin when he is wearing the scarf pin that its nature can be discovered. The first thing to attract attention is the buzzing of the machine, which, by means of a current obtained from a small chloride of silver battery carried in the vest pocket, is kept in operation at a high rate of speed and with a noise like a small nest of hornets. The field magnets of the little motor are made of two thicknesses of No. 22 sheet iron scraped down and polished. These are held together with gold screws, and wound with No. 20 silk-covered wire. The armature is of the four-pole type, and is wound with No. 36 wire. The little brushes are of marvelous thinness, having been constructed of copper, hammered down with much patience and care. There is a small gold switch on a black rubber base, made with a pin, to be worn on the lapel of the vest.

SELECTED FORMULÆ.

Destruction of Animal Parasites.—For destroying lice on animals the following has been recommended:

Green soap	10 ounces.
Wood alcohol	10 "
Naphthalin	2 "
Water	40 "

Dissolve the naphthalin in the alcohol, add the remaining ingredients, heat gently, and stir until well mixed.

Rub the places infested, and wash off well the next day with water. When the animal is dry, repeat the operation. The second application, it is said, will be sufficient to destroy all the parasites.

Another preparation is made as follows:

Tobacco leaves (not manufactured)	5 parts.
Hot water	60 "

Infuse for half an hour and add

Alcohol	10 "

This is used as is the preceding.

For the prevention of "scab" in sheep, which results from the burrowing of an acarus or the destruction of the parasite when present, various preparations of a somewhat similar character are used. The following formulas for sheep dips are taken from a report on "Animal Parasites," by Dr. Cooper, published by the United States Department of Agriculture:

CARBOLIC ACID DIP.

Soap	1 lb.
Crude carbolic acid	1 pint.
Water	50 gal.

Dissolve the soap in a gallon or more of boiling water, add the acid and stir thoroughly.

KEROSENE EMULSION DIP.

Fresh skimmed milk	1 gal.
Kerosene	2 "

Churn together until emulsified, or mix and put into mixture a force pump and direct the stream from the pump back into the mixture. The emulsification will take place more rapidly if the milk be added while boiling hot.

Use 1 gallon of this emulsion to each 10 gallons of water required.

KEROSENE SOAP DIP.

Soap	1 lb.
Water	1 gal.
Kerosene	2 "

Bring the water to a boil and dissolve the soap in it; then add the kerosene and churn until emulsified.

Use 1 gallon of this emulsion to 8 of water.

These are perhaps rather adapted for prophylactic use. Formulas for other preparations, apparently more active, are given below:

TEXAS TOBACCO DIP.

Tobacco	30 lb.
Sulphur	7 "
Concentrated lye	3 "
Water	100 gal.

Steep the tobacco in three successive portions of water, expressing each time; then add the other ingredients to the liquor, and stir well while in use.

LAW'S DIP.

Tobacco	16 lb.
Oil of tar	3 pints.
Soda ash	20 lb.
Soft soap	4 "
Water	50 gal.

Steep the tobacco as in the previous formula, and add the other ingredients to the liquor.

ZUNDEL'S CARBOLIC DIP.

Crude carbolic acid	3 lb.
Caustic lime	2 "
Potash	6 "
Black soap (or soft soap)	6 "
Water	70 gal.

Mix and boil.

DR. KAISER'S CARBOLIC DIP.

Tobacco	$13\frac{1}{2}$ lb.
Soda	8 "
Freshly slaked lime	4 "
Black or soft soap	8 "
Crude carbolic acid (50 per cent.)	4 "
Water	66 gal.

Infuse the tobacco in the water, strain, and to the infusion add the remaining ingredients.

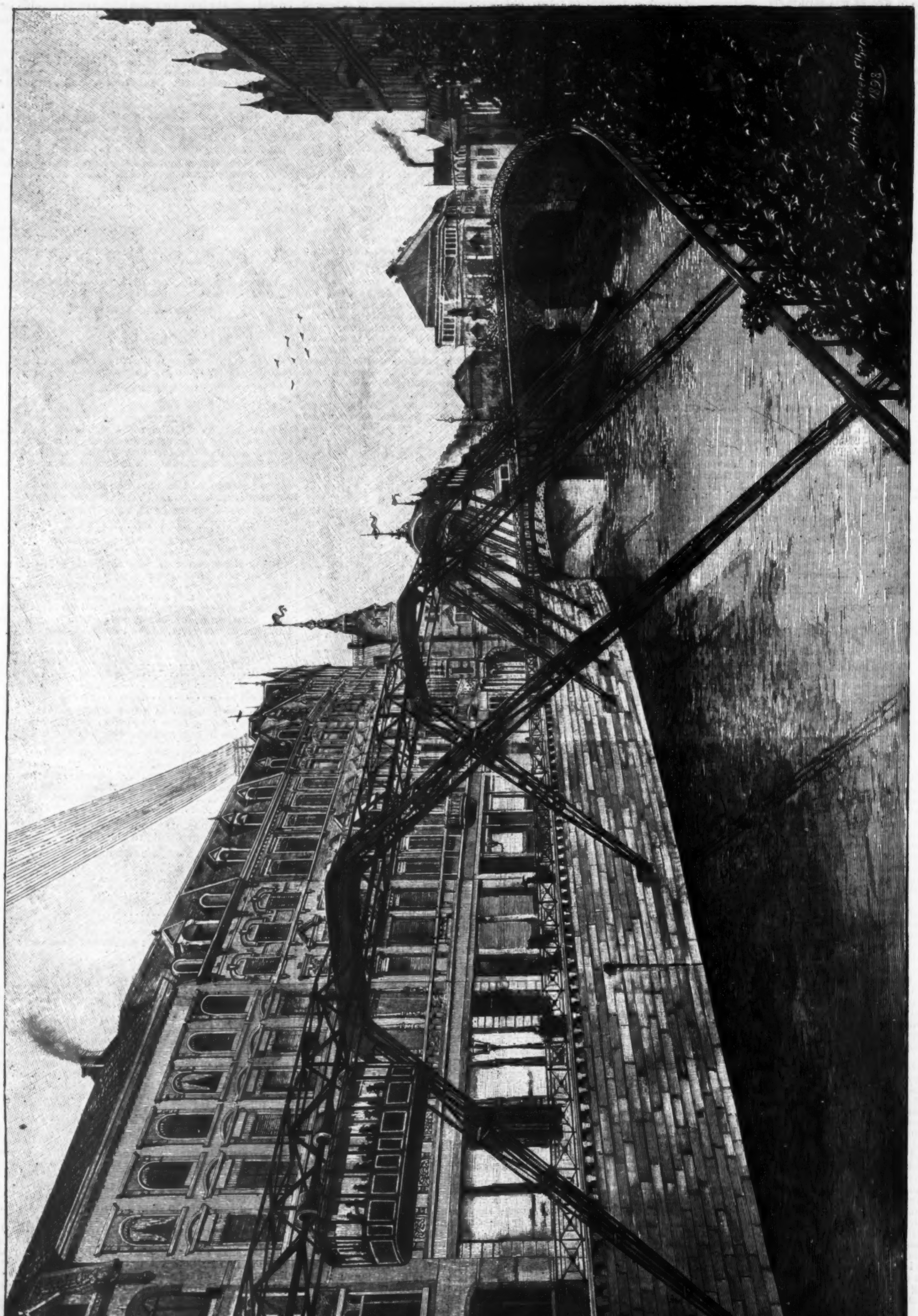
The sheep is immersed in the liquid for, say, half a minute, care, of course, being taken that none of it gets into the mouth, nose, or eyes of the animal.

The quantity of dip required for each sheep is variously estimated at from one quart to one gallon. For small numbers of sheep, say fifty to one hundred, the larger amount is necessary, while for large flocks one quart for shorn or two quarts for unshorn sheep may be allowed. The dip should be kept while in use at a temperature of from 100° to 110° F. The sheep should be dipped again within some six to ten days of the first dipping, in order to kill before their maturity any parasites which may have developed from the eggs which were left upon the animal at the time of the first treatment, as the dip does not destroy the vitality of the eggs.

Instead of treating the scab by one application, some authorities advise the use of a preliminary dip of alkaline water to soften the scabs, or of oil or glycerin well rubbed in for the same purpose. This is to be followed in two or three days by a poisonous dip. Nearly all advise that the scabs be rubbed with a stiff brush while the sheep is dipped.

Preparations like the foregoing will presumably prove efficacious for removing ticks also or any parasites.

Arsenic has been much used in the preparation of "dips," but it is very objectionable, on account of the danger of handling, the risk of poisoning the sheep, and from the fact that it is practically impossible to remove all of the poison adhering to the wool.—Druggists' Circular.



ELECTRIC SUSPENSION RAILWAY (EUGEN LANGEN SYSTEM) BETWEEN ELBERFELD AND BARMEN, AS IT WILL APPEAR WHEN FINISHED.

AN ELECTRIC SUSPENSION RAILROAD.

The thriving Prussian towns Elberfeld and Barmen are connected by an electric street railroad which has proved inadequate for the constantly increasing traffic. The need for something better has long been felt, and some years ago plans were made for an elevated road—such as is now being built in Berlin by the firm of Siemens & Halske—over the River Wupper, but the project was abandoned because it would have been necessary to place the supports in the bed of the river and it was thought they would not be safe at high water. The suspension road of Eugen Langen seemed very well adapted for the location, and, therefore, it was decided to erect an elevated road of this kind, which is now in course of construction.

The structure consists of a number of A frames, the diagonal struts of which rest on foot-plates placed in the banks of the river, and these frames are connected by a system of longitudinal girders. Where the road passes through the street, vertical struts are substituted for the inclined ones. The stations, which are about 1,600 feet to 1,900 feet apart, can be reached by stairways from the bridges over the Wupper. The cars hang from a rail mounted in the girder system, the axles of the wheels resting in movable frames so arranged that the cars, although comparatively long, can move with ease around even sharp curves. The cars accommodate fifty or sixty passengers.

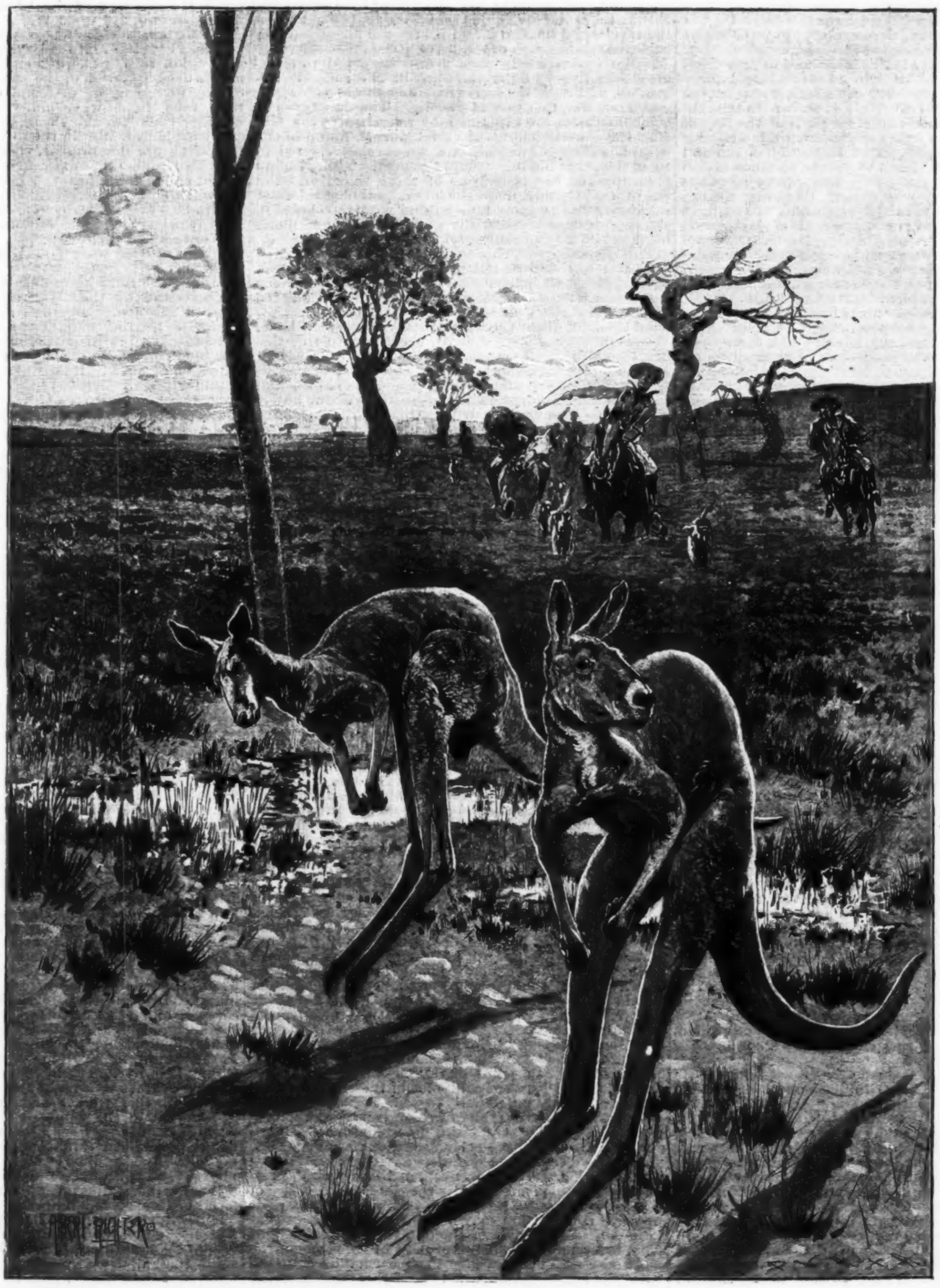
The engineers maintain that this road is considerably safer than other railroads, as it is impossible for the cars to fall from the track, and in case an axle should break the clutch device provided would act immediately. A special device has been arranged for preventing the swaying of the cars. The road has been so built that the lower edges of the cars will be sixteen feet above the roadways of the bridges over which they pass. The cars will run by electricity at a speed of about twenty miles an hour.

The estimated cost of the road is from $2,000,000 to $3,000,000, and it is expected that it will be finished in two years. The work is being done by a Nuremberg firm.—We are indebted to Illustrirte Zeitung for the engraving and particulars.

KANGAROO HUNTING IN QUEENSLAND.

The strange form of the kangaroo, now familiar to every schoolboy, should find a place in the escutcheon of Australia, for in that country alone is this peculiar animal found, and in such numbers that the European inhabitants considered it necessary to begin a work of extermination in the interests of civilization. Australia, which to us is the youngest of all countries, is, nevertheless, the oldest, scientifically considered; its fauna and flora having ceased to attain higher forms, present to a European an appearance of incomplete development. Thus the kangaroo seems as if the upper portion of its body had grown insufficiently, and as if the posterior portion alone had been developed. In order to move itself along, the animal employs its hind-legs and long, muscular tail exclusively. The tarsi of the feet are unproportionately developed, the toes being long and strong, the middle one having a long, powerful, hoof-like nail.

The kangaroo is the only game worth hunting in Australia. The natives, when hunting the animal, usually ambush a part of their number, while the others, slinking up with the utmost caution to the grazing herds, suddenly leap up with loud cries and drive the stupid, fearful animals toward their hidden companions. The kangaroo is also hunted by the natives with ropes and traps. The wealthy European settlers, however, usually employ hunting dogs in chasing their game, which, in spite of its exceeding agility, can be overtaken by a well-trained dog, especially on marshy ground, where the struggles of the game to move onward only cause it to sink still deeper into the soil. The chase is often coupled with danger to the dogs, for the kangaroo, with its powerful hind-legs and tail, often inflicts serious wounds on its pursuers. If a lake or river happens to be in the vicinity, the hunted animal hastens to the water and there awaits the arrival of the dogs. Owing to its size and to the abnormal development of the hind-legs, the kangaroo is enabled to stand in water so deep that a dog is compelled to swim in order to keep afloat. The first dog that approaches, the kangaroo attacks with his fore-feet, and, forcing him under water, drowns him, unless another dog comes to the assistance of his fellow or a bullet disables the kangaroo.



KANGAROO HUNTING IN QUEENSLAND.

The meat of the kangaroo is not considered palatable, and is eaten only in cases of necessity. In Australia the hide of the animal is worth at the most 50 cents, but is said to be as good as calfskin. Near the coasts the kangaroo is rarely met with, but on the prairies of the interior large herds may still be found.—Illustrirte Welt.

The balloon in warfare seems likely to have seen its best days, in view of the discouraging experience of the United States troops with the balloon at Santiago. It is evidently mere foolhardiness to send up observation balloons within range of the enemy's guns; but modern infantry rifles and light artillery can send projectiles so far that a balloon sent up out of range will be too far from the enemy's lines to discover any facts of importance, unless the weather is unusually clear.

[Continued from SUPPLEMENT, No. 1188, page 19052.]

COLOR VISION.*

ANOTHER cause of false color appreciation, insisted upon by Hering, is the pigmentation of the macula. This is certainly of importance. In experiments with color disks the apparatus, to secure consistent results, must always be placed at the same distance from the eye. A color match made with the disks close to the eyes will in general not hold if the observer steps back a few feet, because the macula covers in the two cases a very different portion of the retinal image of the disks. The region corresponding to the macula, indeed, can generally be seen projected upon the surface of the revolving disks as a spot inclining more to reddish than the remainder of the surface. The intensity of the yellow pigment, differing in the eyes of different people, must affect their general perception of color.

The well marked divisions of the color blind, into green blind and red blind, as they would be called in the Young-Helmholtz theory, were explained by Hering as due to the more or less deeply pigmented macula. But the utter inadequacy of this explanation has been abundantly shown.

Perhaps the most striking difference between the Hering hypothesis and the facts is shown in the distribution of color sense in different parts of the retina. Ability to distinguish colors decreases gradually from the center to the exterior. The distinction of red and green disappears first, then the yellow becomes uncertain, and finally blue disappears, the outer zone of the retina being devoid of color sense. The zones are not well defined, varying with the brightness of the light and the size of the colored surface. But making due allowance for these circumstances, the area within which red is distinguishable differs from that occupied by green, and the yellow sensation differs in extent from the blue. If red and green, or yellow and blue, are due to the presence of the same visual substance, it seems that the boundaries should be coextensive.

Even the sensation of white presents similar variations. There are, as has been already said, three cases in which the color sense is wanting: the totally color blind eye, the normal eye in faint light, and the periphery of the retina. The brilliant discovery of Hering, in 1891, that the distribution of brightness in the spectrum in the first two cases is the same, aroused great interest in the theory of the sensation of white, and went far toward establishing its position as a distinct and separate sensation. The third case, it was taken for granted, fell under the same law. But in 1896 Von Kries showed that the distribution of brightness in the spectrum as seen by the outer zone of the retina is different, being practically the same as in the central portion, with its maximum in the yellow, and that the peripheral zone in the retina of a color blind person shows the same deficient sensation for the longer wave lengths as in the color perceiving portions of the eye.

This is a matter of so much interest, that I have reexamined it with the flicker photometer, with results differing materially from those of Von Kries. According to my experiments, the brightness of the colors of long wave length diminishes continually, while that of the shorter wave lengths increases continually, from the center of the visual field to its circumference. The conditions under which Von Kries worked, however, were so different from mine, that I cannot regard my results as so far as necessarily invalidating his. If his results are confirmed, they show that the sensation of white in the normal eye is not completely determined by the twilight sensation, or that of the totally color blind. It contains elements derived from or connected with the mechanism producing the sensation of color, even in those portions of the retina where no color sensation exists.

I have discussed these two theories somewhat at length, because our growth in knowledge of the facts of color sensation has been conditioned largely by their existence. The enormous amount of work which has been done on the vision of the color blind, on color vision, by varying illumination, on peripheral color vision, not to mention researches upon more purely subjective phenomena, has been largely suggested by aspects of one or the other of these theories, or undertaken with a view to testing portions of them, and there has seemed no better method of exhibiting the results of these researches than by placing them in connection with the hypothesis they were intended to test. I need hardly add that I have been greatly aided in this summing up by the polemical writings emanating from the hostile schools.

In this respect, at least, the two theories have been eminently useful, and have fulfilled one of the chief requirements of a scientific theory—that its explanations can be tested by experiment. The earlier forms of color-theory suggested by Newton and by Young were hardly such. So long as the specific effect was conceived to be entirely in the central organ, to which the nerves merely communicated the vibrations of light, there was little upon which to base experimental work. Helmholtz, by ascribing the specific activity to the nerve ending itself, made it necessary to describe this activity in some definite way, which could then be tested. The very simplicity of the conceptions of Helmholtz and Hering, at first the apparent guaranty of their truth, has proved their greatest value, but also their greatest difficulty.

It is not to be wondered at that later theorists have attempted to modify one or the other of these hypotheses, instead of starting anew. Many such attempts have been made in the last few years, but few have attained more than a passing notice, and none any general acceptance. One or two, however, are of considerable intrinsic interest, and may command attention for a brief period.

Ebbinghaus attempts to advance a step upon the older theories by assigning to a particular retinal substance the function of color stimulus. He finds this substance in the so-called visual purple, which was studied with great care by Kühne more than twenty years ago. This remarkable substance is reddish purple in its normal condition. On exposure to light it bleaches rapidly, passing through a series of tints until it becomes yellow. On further exposure to light it becomes colorless, but in the dark regains its original purplish tone directly without passing again through the series of changes in color. The color stimulus is ascribed by Ebbinghaus to the absorption of light by the visual purple, and the character of the light sensation is directly dependent on the color of the light absorbed, that is, upon the physical properties of the substance.

The purple substance, which is changed by the action of light into the "visual yellow," is identified by Ebbinghaus, in its two stages, with the "yellow blue" substance of Hering. In its first stage it gives rise to the sensation of yellow, in the second stage to that of blue. The visual purple pertains to that element of the retinal complex known as rods. These are not present in the central portion of the retina, and the visual purple is apparently absent there also. But the fovea is sensitive to blue and yellow, as also to green and red. Ebbinghaus supposes that a red green substance exists, even in the fovea, green in its first stage, red in its second; that the yellow blue substance exists also in the fovea, but that the two, present there in about equal quantity, and nearly complementary in color, neutralize each other, leaving the fovea colorless. A white sensitive substance is also supposed to exist, more sensitive to light than any of the colored substances, and thus we arrive at three sets of color processes, similar to those of Hering. The two types of color blindness are explained by reference to the fact that there are two kinds of visual purple, found in the eyes of different animals, one more relatively red in tone, the other inclining more to violet. The red blind are supposed to possess one of these, the green blind the other. Certain anomalous and pathological color sensations are supposed to be due to disturbances in the conducting nerves, or the central organs, and hence need not be fitted into the scheme thus outlined.

The physiological character of this theory, as Mrs. Franklin has shown, can probably not be sustained. It is difficult to believe that such a balance between the visual purple yellow and the supposed visual red green could exist, in all stages of both, that they would remain always complementary, and so the latter always invisible. Yellow light, according to this theory, should be most active upon the visual purple, but, as a matter of fact, this material is bleached very slowly by sodium light, and, indeed, König has shown that its maximum absorption is not in the yellow, but in the green. The visual purple exhibits other striking properties of which the theory takes no account. It seems probable, on the whole, that the office of this substance is really a very different one, and that if it is concerned at all with vision, it is with the sensation of white light, not colored.

The theory of Ebbinghaus, then, if we deny its connection with the visual purple, rests upon the same basis as that of Hering, a visual substance not identified, perhaps not discoverable, but recognizable only through the precision with which it explains phenomena, and the hypothesis itself becomes in the main a modification of Hering's, with the well known pairs of photo-chemical substances, modified in their character so as to meet the facts more perfectly, removing some difficulties, but introducing others.

The chief advantage of the hypothesis for explanatory or speculative purposes lies in its greater freedom. The theory of Hering demands six color processes. These are so connected together that they make not six, but three independent variables. Ebbinghaus so constructs his substances as to leave them nearly independent, the blue, for instance, no longer serving as the antagonistic substance to the yellow, but regarded as developed out of it, and possessing specific properties of its own. Under certain conditions the color substances are supposed to neutralize each other, as with Hering, a supposition which adds greatly to the difficulty of the hypothesis, but in general, five independent variables are at the command of the theorist which, it is evident, may be endowed with such various properties as to explain almost any conceivable difficulty of color vision.

It may also be said that, with such an assortment of visual substances at command, the properties of which have at present no known chemical, physical, or physiological relations, but are deduced entirely from the sensations dependent upon them, the phenomena might probably be explained in an indefinite number of ways, and the different methods of explanation should be regarded rather as examples of ingenious speculation than as real contributions to the advancement of science.

To such a category belong many of the later theories of vision. They incline to Helmholtz or to Hering according as their point of view is chiefly physical or psychological; for the standpoint of these two theories is fundamentally different.

Helmholtz, showing that all colors can be compounded from three, and that white may be also compounded, assumes that three color sensations are sufficient, and that white may be regarded as a compound sensation. Hering, relying more upon the direct deliverances of consciousness, denies the compound nature of the sensation of white and of yellow, whatever their physical composition may be, and says explicitly that "the entire separation of the optical nature of a light from the sensation which it arouses in us, is one of the most necessary prerequisites to a clear handling of the theory of color." Along the lines of these two theories, then, new hypotheses move, and will move, since each of them stands for something real, and has its own distinct advantages.

Upon a somewhat different basis rests a theory, hardly so much of color as of light sensation, which was hinted at by various observers, but most clearly worked out by Von Kries. This supposes that we possess two entirely distinct kinds of visual apparatus, one dependent upon the cones of the retina, the other upon the rods, and the visual purple connected with them.

Max Schultze, so long ago as 1866, mainly on anatomical grounds, suggested that the rods were probably the most important organs of vision in faint light. Animals which prey by night, as cats, moles, owls, etc., possess retinas rich in rods, but with cones either few or absent. Our own eyes perceive faint light more readily with the peripheral portions of the retina, where rods are numerous, than with the central portions, where they are few.

Helmholtz* pointed out the fact that if the visual purple is actually connected with vision, it must have to do with peripheral, rather than central vision, since it is absent from the fovea, and suggested that it might have to do with the perception of faint light.

In 1894 König studied the absorption curve of the visual purple, finding it substantially identical with the curve of brightness for the spectrum of low luminosity. Von Kries, combining these and other suggestions, considers the visual purple in the rods to be, in the human eye at least, the active agent for the perception of faint light. He shows that the phenomena of adaptation point in the same direction. In strong light the visual purple is soon bleached. An eye "adapted for brightness" is very deficient in power to perceive faint light. If it is now kept in darkness for about half an hour, this faculty is enormously increased. But in about the same period the visual purple is practically restored. The essence of adaptation is the recovery of the visual purple. Red light, which does not act upon this substance, does not destroy the sensitiveness to faint light in an eye which has been exposed to it for even a considerable time.

If vision by faint light depends, wholly or partly, on the decomposition of the visual purple, and if light of long wave lengths does not effect this decomposition, blue light when faint should appear much brighter than red, and Purkinje's phenomenon is thus easily explained. But in the fovea, where the rods and the purple are not present, this sensation of colorless faint light should not exist, and the color of any light bright enough to affect this portion of the retina at all will at once be recognized. Von Kries declares this to be a fact. Two colors, equally bright in strong light, will remain so at all illuminations if their image falls entirely on the fovea; but, if not, the color which is of the shorter wave length will in general be the brighter.

Vision by strong light, and color vision, since both are possessed by the fovea, must be effected by the mechanisms of that retinal area, and these sensations Von Kries attributes to the cones, which are supposed to be furnished with a trichromatic color apparatus, and to afford the sensations of color and a compound sensation of white. If objection is made to the compound white, the details of this latter apparatus might be varied, might even approximate that of Hering's theory, without affecting the importance of the hypothesis, the essence of which is the twofold nature of the sensation of brightness.

Such a theory explains easily the fact that grays compounded from different pairs of complementary colors, and equally bright in ordinary light, cease to be so in faint light. They are equalized at first by the cone apparatus, and are seen in the faint light chiefly by the rod apparatus, in which the scale of brightness is entirely different.

G. E. Müller makes the acute suggestion that the visual purple may not be a visual substance at all, properly speaking; but, while concerned chiefly with the phenomena of adaptation, may act also as a sensibilizator—to borrow a photographic term—for the white sensitive substance, increasing its susceptibility in faint light. This modification of Von Kries' hypothesis is, perhaps, simpler than the original and equally satisfactory.

Still another hypothesis for separating the white from the color sensations is, that the sensation of white, from an evolutionary standpoint, was developed earlier than the sensations of color, and that the mechanisms of the latter are to be regarded as evolved from that of the fundamental sensation, and as modifications of it. Upon this idea Mrs. Franklin has founded her ingenious theory of light sensation. Abney has made a similar suggestion, but in general terms only.

Such is a brief and hasty summary of the progress of color theory. We may well ask for the result. In the general shifting, what views have maintained or gained a footing? A few, I think, are fairly well established.

1. The number of color sensations is small, and all color theories positing a large number are to be distrusted. If experimental work is of any value whatever, it is certain that all light sensations, for all purposes, may be expressed by a small number of variables. The Young-Helmholtz theory demands three. Hering's requirements, as Helmholtz has shown, may be expressed in terms of three, although the number of fundamental color sensations using color in its ordinary sense is four. Such theories as those of Von Kries and Mrs. Franklin require four variables, such as that of Ebbinghaus five. The introduction of a much larger number is gratuitous and unnecessary.

2. Out of this number of variables at least one is to be allotted to the white sensation, or that which is closely akin to it, the sensation of brightness. It is no longer possible to think of white entirely as a compound sensation, however it may be compounded physically. It is unnecessary to recapitulate the arguments for this statement, drawn largely from the three forms of total color blindness.

3. White, however, can hardly be thought of as an entirely independent sensation. The phenomena of vision by faint light, the facts of peripheral vision, show that, under certain circumstances, color sensations contribute their quota to the colorless one, and in differing amounts at differing brightness.

These phenomena are not satisfactorily handled by any of the principal theories. They are fairly well explained by the Helmholtz suggestion of shifting color curves, nearly as well by the hypothesis of Hering and Hillebrand, that color sensations possess specific brightening or darkening power, which makes itself more notable as the intensity increases. These are but formal explanations, however, and increase rather than diminish the difficulties of the theories to which they are attached.

4. The theory of Von Kries, of different visual mechanisms for bright and faint light, supplements excellently the existing theories, and must be regarded as a distinct step in advance.

5. A definite and highly probable function has been assigned to the visual purple, the function of adaptation, and of causing or aiding vision in faint light.

Farther than these at present we can hardly go. The number and variety of known phenomena are great, and constantly increasing. Their inter-relations grow every day more complex, and the actual mechanism governing those relations still remains almost en-

* Address by Frank P. Whitman, Vice-President and Chairman of Section B, and delivered before the American Association for the Advancement of Science.

* Physiol. Optik., 2d ed., p. 268.

tirely unknown. Subjective experiment appears likely to yield little more aid. The various theories have arrived at such a state of perfection and, thanks to subsidiary hypotheses, to such a state of flexibility, that almost any visual result might probably be explainable by either. Perhaps the most hopeful line of research is that which, like König's study of the visual purple, seeks to find some relation between color sensations and physical properties. Since so many phenomena point to photo-chemical changes in the eye, it would not be surprising if the next advance should come from the chemical side, rather than from the physiological, physical, or psychological, which have held the field so long.

[Continued from SUPPLEMENT, No. 1188, page 19054.]

THE DEVELOPMENT OF PHOTOGRAPHY IN ASTRONOMY.*

IT was not until the study of the peculiarities of comet tails with portrait lenses that we knew anything of the strange phenomena shown by them. It may be said that our knowledge of the extremely rapid transformations in the tails of comets dates from the photographs of Swift's comet of 1892, taken at the Lick observatory with the lens previously mentioned and similar ones taken of the same object by Prof. Pickering at Arequipa. Although the great comet of 1882 was successfully photographed, it showed no phenomena not known and already seen with the telescope. While only an insignificant affair visually, and but fairly visible to the naked eye, Swift's comet showed upon the photographic plates the most extraordinary and rapid transformations yet seen in any comet. One day its tail would be separated into at least a dozen individual streams and the next present only two broad streamers, which a day later had again separated into numerous strands, with a great mass, apparently a secondary comet, appearing some distance back of the head in the main tail, with a system of tails of its own. This remarkable appearance was the first known of its kind, though it was repeated in photographs of Rordame's comet of 1893 by Prof. Hussey. These peculiar phenomena seem to be a production of the comet itself—a result of the forces at work in the head of the comet.

The photographs of Brooks' comet of 1893, also secured with the Willard lens, showed such an extraordinary condition of change and distortion in the tail as to suggest some outside influence, such as the probable collision of the tail with some resisting medium, possibly a stream of meteors, such as we know exist in space. The long series of photographs obtained of this comet frequently showed great masses of cometary matter drifting away into space, probably to become meteor swarms. One of the pictures showed the tail of the comet streaming irregularly as if beating against a resisting medium and sharply bent at right angles near the end, as if at that point it encountered a stronger current of resistance. All of these wonderful phenomena would have been unknown to astronomers had it not been for these photographs, and the comet, instead of proving to be one of the most remarkable on record, would have passed without special notice. Though these phenomena were so conspicuously shown, scarcely any trace of the disturbance was visible with the telescope. On account of the apparent insignificance of the comet visually, no photographs were made of it elsewhere during its active period.

In the matter of discovery the photographic plate has accomplished a very great amount in certain directions. In spectroscopic work it has a field singularly suited to display its possibilities. In this direction it deals not alone with what can be seen, but it enters into the unseeable regions where the eye takes no cognizance of things. For though it is partly blind to the light which affects the eye, it can readily penetrate regions where we in turn are blind. And it is in this direction mainly where the photographic discoveries in spectrum analysis are immediately concerned, since it extends our vision into the invisible regions of the spectrum. The result must necessarily be one of discovery. It not only faithfully records spectral lines that cannot otherwise be seen, but by special treatment of the plate it also registers those visible to the eye and permits their accurate measurement.

From Doppler's principle it is known that the spectral lines have a normal position only while the object whose light is under examination is motionless in the line of sight. When it is in motion to or from us these lines are displaced from their normal position, in the first case toward the violet region of the spectrum and in the other toward the red. By comparing any of the lines in the spectrum of a heavenly body with the same lines in the spectrum of a stationary object, it is possible to tell not only the direction of motion of the moving object, but to accurately determine the amount of this motion, for there is a known relation between the amount of displacement and the actual velocity, and this is independent of the distance.

This peculiarity, besides showing the motions of the individual stars, has revealed to us, through the aid of photography, an entirely new class of bodies, the so-called spectroscopic binaries.

The visual spectroscopic work long ago, in the hands of Dr. Huggins, had shown the displacement of the spectral lines as the stars moved toward or from us. It remained, however, for photography to further extend this remarkable work by showing that not only were the lines displaced, but that in the case of certain of the stars the lines were periodically doubled at short intervals, thus indicating the presence of two bodies which must be rapidly revolving about each other. The doubling of the lines is due to the alternate approach of one and recession of the other body, which thus causes a displacement of the two sets of spectra, for when the motion is at right angles to the line of sight (and this must occur at two points in the orbit) the two spectra will be exactly superposed. It can readily be shown from the known periods of these stars and their enormous distances that no telescope is likely to be made so powerful as to show visually their independent components. The visual double star having the shortest period is one discovered by Burnham, and known as Kappa Pegasi, which he found to have a period of about eleven years. The spectroscopic binaries seem to revolve in extremely short periods—a few days—and in at least one case in a few hours, showing that they must be extremely close to each other. The explanation, to account for the observed peculiarities of their spectra, that these are actual double stars in rapid orbital motion must be accepted until some better explanation of the phenomenon be forthcoming, which does not at present seem likely to occur.

Among the first of these spectroscopic binaries discovered was Beta Aurigæ, which was detected at Harvard College observatory by Miss Maury, through the doubling of its spectral lines as shown on the various photographs obtained of it at that observatory. This star has a period of four days, the relative motion of the components about each other being about 150 miles a second, and the distance between them about 6,000,000 of miles. In a similar manner, Dr. Vogel has found that the star Algol, so famous for its light variations, alternately approaches us and recedes in a manner that can only be explained at present by the revolution of that star about some other body or about the center of gravity of the two. The spectrum of this star does not show any doubling of the lines, but a simple displacement from one side to the other of their normal position occurs consistent with the changes of the star's light. As there is no doubling of the lines, the conclusion is that there is but one spectrum. One of the stars is, therefore, a non-luminous body, and hence produces no spectrum. The old explanation of two hundred years ago, that the variations in the light of Algol are due to a dark body revolving about it and partially eclipsing it at intervals of a little less than three days, is hence proved by the spectroscope and photography to be the correct one. The frequent discovery of these spectroscopic binaries shows that they are by no means uncommon, and that possibly a considerable percentage of the stars consist of two or more bodies rapidly whirling about each other.

The beautiful phenomenon of the displacement of the spectral lines through motion in the line of sight has given rise to many important and interesting results, but certainly none more striking than that offered by Prof. Keeler's spectroscopic proof of the meteoric constitution of the rings of Saturn. It was suggested soon after the discovery of the rings that they must be made up of discrete particles revolving in zones about the planet, which, from their smallness and great distance from us, gave the appearance of a system of solid rings encircling Saturn. This had been shown by Clerk Maxwell to be a mathematical necessity, and as the rings lay within Roche's limit, within which a large solid body would be broken up in revolving about a planet by the unequal attraction of the planet itself, it was certain that the rings must consist of small individual bodies. It remained for the spectroscope, through the aid of photography, to add its testimony to that of mathematical analysis. The problem offered to the spectroscope was simply to show whether the inner or outer portion of the rings moved the faster. Should they revolve as a solid body, the outer edge must necessarily have the greater velocity. But if they are made up of individual particles, then the attraction of the planet would cause those nearest to it to move the fastest, or, in other words, the inner part of the rings must have the greater velocity. This beautiful problem was successfully solved by the photographs of the spectrum of the rings obtained by Prof. Keeler, where the displacement of the spectral lines by motion in the line of sight showed that the inner portion of the rings moved faster than the outer, and hence that the rings must consist of small bodies responding individually to the attraction of the planet.

The discovery of variable stars by photography can be compared with the wholesale business in commercial circles, because of the great number that are found on the various plates. These stars are not only found by the actual variation of their light, as shown by the size of their images on different plates, but many of them also show peculiarities in their spectra which at once stamp them as being members of a certain class of variable stars. So expert has Mrs. Fleming, of the Harvard College observatory, become in detecting these bodies by their spectra that she instantly recognizes them at a glance among hundreds of other spectra on the same plate.

The most interesting and important of these Harvard College variable-star discoveries are found in the photographs of the globular clusters taken by Prof. Bailey with the 13-inch telescope at Arequipa, Peru. It was found that a great many of the small stars that make up these clusters varied regularly and rapidly in their light, and in some cases a large percentage of the entire mass of stars was variable. So abundant are these variables, indeed, that as many as a hundred of them have been found in a space in the sky that would be covered by a pin's head held at the distance of distinct vision.

The clusters most prolific in variables are M 3, Omega Centauri, M 5, and a few others of this class. Perhaps the most remarkable circumstance, outside of the actual grouping of variables in such great numbers, is the fact that not a single variable star has been found in the great cluster of Hercules, the best known of these objects, and apparently like them in all other respects. Prof. Pickering finds every star in this cluster constant in its light from the photographic evidence extending through ten years. This would seem to mark this great cluster as being physically very different from the others referred to.*

The writer has examined the cluster M 5 with the great telescope of the Yerkes observatory and has visually verified a number of these variables. The brighter of them appear to vary slowly in their light, while many of their smaller ones are extremely rapid, passing through their entire light changes in a few hours. In the discovery of such objects, photography offers special advantages, since on the different photographs a thousand or more stars can be rapidly and accurately compared with each other and any variation in their light at once detected, while such comparisons in the actual sky, visually, would be limited to a very few stars. By the aid of the Harvard photographic plates over five hundred variable stars have been discovered in these clusters. It must be said, however, in speaking of the variables in the cluster M 5, that the two most prominent ones were really discovered visually nearly ten years ago by Mr. D. Packer with a very small telescope. These two seem to have been the first of the variable stars found in this cluster.

The shortest period variable so far discovered in the globular clusters—indeed, the shortest known variable—is a small star in the great southern cluster Omega Centauri, whose period is seven hours. These cluster variables seem to form a distinct class from the ordinary variable stars. It is very interesting to watch one of these small stars in a powerful telescope and to see with what quickness it passes through its light variation. One of the small stars in M 5, whose period is 12h. 31m., seems to be dormant for a large part of the time, as a very faint star, invisible in ordinary telescopes. It begins to brighten, and in two or three hours has risen nearly two magnitudes and faded again to its normal condition, while another and larger star quite near it seems to require a month or more to go through its light fluctuation.

Frequent reference has been made to the photographic work of the Harvard College observatory. It is to be regretted that time does not permit a more detailed account of this work. No other observatory is so active in the application of photography to the various departments of astronomy. Not content with the available sky as seen from the northern hemisphere, Prof. Pickering wisely established a branch observatory at Arequipa, in Peru, where a thorough photographic survey of the southern skies has been made, and a vast amount of work of high value has been accomplished, which has resulted in many important discoveries among the southern stars.

In dealing with the ordinary stars of the sky, it has been shown that measures of the relative positions of the photographic images are strictly comparable with meridian circle work, while the number of stars that can be measured is vastly greater. The Pleiades, the cluster of Perseus, Præsepe in Cancer, etc., have all been measured with the micrometer, the heliometer, and by photography.

The comparisons have shown that photography has many advantages over the older methods, and the results are possibly even more accurate. These objects, however, are loose clusters, and the stars are not thickly crowded, and, moreover, the small scale of the photographic plate does not in such cases seriously interfere with the work. The great globular clusters of the sky, however, from the extraordinarily crowded condition of their stars, would almost forbid any attempt to deal with the individual positions by photography, except in outlying regions, where the stars are thinly scattered. No comparison between photographic and visual measures of such objects has yet been made, because no visual measures exist. The great cluster of Hercules is, perhaps, the easiest of these objects, both visually and photographically. It requires, however, a powerful telescope to measure the individual stars. Dr. Scheiner has given a catalogue of 833 of the stars of this cluster measured on photographs taken with the 13-inch refractor of the Potsdam observatory. The stars that were measured all lie between the magnitudes 11·7 and 14. As a matter of comparison with visual measures, the writer has taken up the measurement of a few stars contained in Scheiner's catalogue. A rough inspection of the results so far obtained shows a close agreement between the visual and the photographic work. These observations also show that no appreciable change has taken place in the positions of any of the stars in the past six years, which, perhaps, is surprising, since one would expect a possible rapid change in some of the positions of the individual stars, where they are massed so close together. They, however, seem to be as stable in their relative positions as are the stars elsewhere in the sky. A more remarkable object with a great telescope is the cluster Messier 5, in which the stars are more closely compressed and irresolvable than in the cluster of Hercules. This object has already been mentioned in speaking of the variable stars discovered at the Harvard College observatory. The measurement of nearly one hundred of these small stars has been undertaken with the great telescope of the Yerkes observatory. Many of them are apparently in the very heart of the cluster, where the compression is the greatest. It is doubtful if at this time photographs can be made of this cluster upon which the crowded individual stars can be accurately measured. It has been frequently photographed, but no measures have been made of the great mass of stars in the center of the cluster.

It has been already stated that the accuracy of the photographic positions of individual stars is as great as the best meridian observations. The facility and ease with which the photographic positions are obtained is well shown in a report by Prof. H. H. Turner, who is making the Oxford portion of the great astrographic catalogue. An average of 3,951 measures per week is obtained. Over 150 stars per hour each can be measured by those most skilled in this work.

In the discovery of nebulæ, variable stars, and asteroids the photographic plate has done a great work, which is still being carried on. The number of known asteroids has been doubled in the past few years (as many as nine have been found in a single night), and now it has become a matter of impossibility to keep track of them all, and they are found and turned adrift again unless they show some striking peculiarity of orbit.

Up to the present time but two comets have been discovered by photography. The first of these was discovered on a photographic plate taken by the writer on October 12, 1892, with the 6-inch Willard lens of the Lick observatory, and was subsequently verified visually and observed at the different observatories. The second was photographed at the same observatory by Mr. Coddington, with the same instrument, in July, 1898.

In photographing the sky it is found that the short focus portrait lens, from its small scale and large field, will show faint nebulosities beyond the reach of the larger photographic telescopes. This results from various causes. The action of these lenses upon the Milky Way, comets' tails, and the great nebulosities of the sky, does not seem to be strictly subject, in practice,

* Address of Prof. E. E. Barnard, Vice-President, before Section A—Mathematics and Astronomy—of the American Association for the Advancement of Science, August 22, 1898.

* Prof. Bailey has since found that two of the stars of this cluster are slightly variable.

to the law of the ratio of aperture to focus; or, if it is, this law must be somewhat modified in effect. The action seems to be quicker with the short focus lens than it should be. Probably, however, much of this is due to the small scale and the consequent compression of the image into a smaller space, which would produce an intensification of its action. It is possible, also, that the photographic plate may be relatively more active with a bright image than with a faint one, which would give an advantage to the small relatively bright image of the portrait lens. The idea seems to be partly borne out by some experiments with a small lantern lens. This lens, 1½ inches in diameter and about 5½ inches focus, is much quicker than its light ratio would warrant, for it will photograph in a few minutes what the ordinary quick-acting portrait lens would require several hours to show. This was strikingly shown in photographs taken with it of the Milky Way. The scale of this lens is very small, and the cloud forms are so compressed that they act as a surface, and not as an aggregation of individual stars, as they must do in a larger telescope. If the focus is increased, the stars are scattered and the cloud no longer acts as a surface. With this small lens the earthlit portion of the new moon was readily photographed in a single second, while with a 6-inch portrait lens of ratio ⅕ from 20 to 30 seconds were required to show it well. The brighter cloud forms of the Milky Way were shown in from 10 to 15 minutes' time, while with the larger lens upward of three hours were required. Some of the diffused nebulosities of the Milky Way, notably in the region of Antares, are shown more quickly and more satisfactorily with this small lens, and a great wing-like nebula involving the star Nu Scorpio was discovered with it.

A list of discoveries made with these small lenses would be tedious; one of the most interesting, however, cannot be passed over, because of its importance. There is no object in the entire heavens better known than the great nebula of Orion. With the lantern lens, a great curved stream of nebulosity was shown on the plates of this region covering a large portion of the constellation and some 17° long. It was found later that this had already been discovered by Prof. W. H. Pickering with a 2½ inch lens in 1889. This object seems to be an outlying appendage of the great nebula. The discovery very much extends our knowledge of the complicated, far-reaching influence of this mysterious object. In several other cases the photographic plate has shown us that the nebulæ are far vaster than we had ever conceived them to be, for their fainter extensions are not seen by the eye. What this knowledge may ultimately lead to in the reconstruction of our ideas of space and its contents can hardly be anticipated just now, though it must, necessarily, very greatly influence those ideas.

We have spoken of the Pleiades and the entangling nebulosities shown by photography to involve the stars of the cluster. The portrait lens has shown us that not only are the individual stars of this group involved in a nebulous system, but that streams and masses of this filmy matter stretch out for great distances all about the cluster.

The photographic plate has shown itself especially adapted, when used with the rapid portrait lens, for the accurate registering of the paths of meteors, and it promises to be of special value during the expected return of the November meteors this year, when a more exact determination of the radiant will be obtained from the photographs, and hence the orbit of the meteor stream will be better known.

In the reduction of the measures of the photographic plates for the great Cape Photographic Durchmusterung, Kapteyn discovered another "runaway" star with a proper motion of 8·71 seconds a year, which is much greater than that of the celebrated 1830 Groombridge, and is at present the largest proper motion of any known star.

There are very few departments of astronomy where photography has not taken a prominent, if not a commanding position. It is probable, however, that it will never take the place of the micrometer in the observation of the close double stars, and in this direction the micrometer of Burnham will, perhaps, never be displaced. The photography of the surface features of the planets is in an almost hopeless condition at present, yet much can be expected in this direction when an increased sensitiveness of the plates has been secured.

Photography has shown its value in the determination of stellar parallax, and probably hereafter it will essentially take the place of the micrometer in this direction.

This is not the place to go into a discussion of the relative values of the refractor and reflector for photographic work. Where accurate measurement is to be considered, the refractor is doubtless better than the reflector. If, however, the main object is a great quantity of light, such as is required for the photography of the nebulæ, the large aperture of the reflecting telescope of short focus makes it, perhaps, the best form of instrument (though it is very much hampered by its small field). This has been shown to be true by Common and Roberts. Since in the reflector the light does not pass through the glass, it is possible to use very large apertures without any additional loss of light through absorption, as would necessarily occur if it passed through a large object glass.

Mr. Ritchey, of the Yerkes observatory, is making a large glass speculum, five feet in diameter and twenty-five feet focus, which, when finished, will be one of the most powerful instruments for photographic and spectroscopic work yet made, and which deserves a more extended notice than my limited time will permit me to give it here. With this instrument and Mr. Ritchey's skill in photographic work, results of high importance will be obtained.

Through the intelligent generosity of Miss Catherine W. Bruce, of New York city, astronomical photography has been placed on a firmer basis than it ever was before. Her gifts have been made to all departments of astronomy, and it would take considerable space to properly enumerate them all. Perhaps the most important of these are the ones that bear directly upon astronomical photography.

The first of these gifts was the great 24-inch photographic doublet, by the late Alvan Clark, presented to the Harvard College observatory, and which is now doing such excellent work in Peru; the two 15-inch portrait lenses for Dr. Max Wolf, of Germany, and a 10-inch photographic doublet for the Yerkes observatory. These instruments are the most powerful of their kind, and for certain classes of work are superior to any other form of telescope. The results of the splendid gifts of this lady must hereafter have the greatest influence upon the higher development of astronomical photography.

It is impossible within the limits of this address to give more than a general, and at best incomplete, sketch of the rise and progress of photography in the various lines of astronomical research. To those who have kept pace with these rapid strides in the last twenty years this brief history will seem imperfect, and perhaps of little interest. Many applications of the photographic art and many valuable results have necessarily been omitted. But few of the names of those prominently identified with this subject have been mentioned, and but little of their work even alluded to. A volume of no small dimensions would be necessary to give a complete history of the development of photography in the many directions in which it has been applied to astronomy. The time to do this has not yet come. Progress has been so rapid and far-reaching that its history, however complete and exhaustive, a year later requires to be rewritten; and there is no reason for supposing that the end, or even the beginning of the end, has been reached. With new materials and new methods, and new workers who will profit by the experience and results gained by those who have in our time accomplished so much, we may expect for the new century far greater results than those briefly recorded here.

It would be difficult just here to predict the future of astronomical photography, though one can foresee something of the great results it must accomplish.

It will displace some of the visual work, but it is more likely to move along new lines—opening up new fields of research.

The older astronomy, so nobly represented by Simon Newcomb and a few others, will be strengthened at every point and will stand all the more sublime for the help it shall receive from photography.

Yerkes Observatory. E. E. BARNARD.

CULTURE AND PREPARATION OF ORRIS ROOT.

THE digging of orris root (giaggiolo) yielded a large crop this year (1897). The principal places of production are the communities of Greve, Dicomano, Pelago, Regello, Bagno a Ripoli, Pontassieve, Galluzo, Santo Casciano in Val di Pesa, Montespertoli. The finest quality of root comes from the villages Santo Polo and Castellina, of the community of Greve.

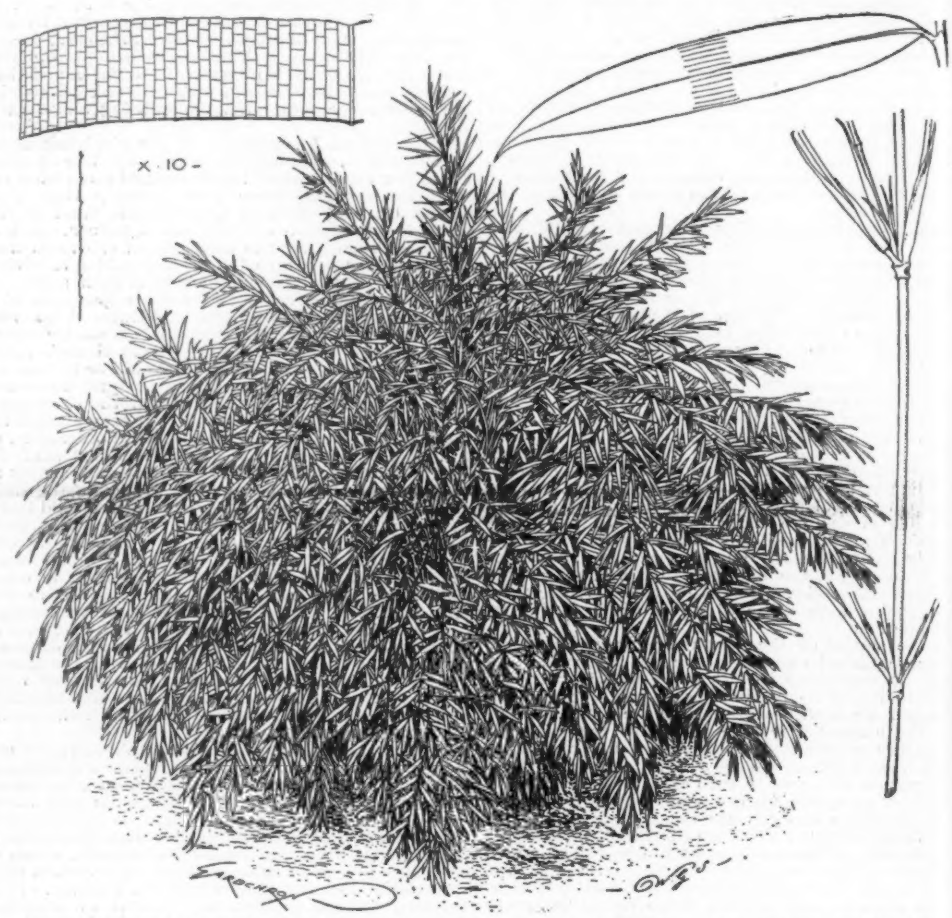
Considerable cultures of orris have gradually been established in provinces bordering on Florence and furnishing roots of equally good quality. They are mainly located in Arezzo, Castelfranco di Sopra and in Lore Ciuffenna, all in the province of Arezzo, further in the province of Grosseto, in Faenza, in the province of Ravenna, and in Terni, in the province of Perugia. The estimated total yield of the crop of 1897 from these districts (Tuscany) is about 1,350,000 kilos, being an increase of 250,000 kilos over the crop of the preceding year.

Next in quality to Tuscany (Florentine) orris root stands the Veronese root. This is, however, inferior in aroma and, therefore, unfit for the distillation of essential oil. This root is mainly cultivated in the communities of Tregnago, Cassano, Illasi, and Monteforte, in the province of Verona. The total yield of the Veronese root in normal years is estimated as amounting to 150,000 to 200,000 kilos.

Statements made some years ago as to the extensive cultivation of orris in Calabria, in Southern Italy, especially in the neighborhood of Reggio, have proved to be unfounded. Orris, Iris florentina L., grows wild near Reggio and Gerace, but not by far in a quantity to make collection of the root commercially profitable, nor has it as yet been cultivated for this purpose. The culture of orris has been going on in Italy for more than two centuries. Although orris root is a special and an important factor in the commerce of Italy, and is of great importance to the perfumery industries in general, no governmental or municipal attention or statistics are directed to the culture and production of and commerce in this commodity. Orris is planted on hills and their declivities, never in valleys, mostly on sunny clearings, or lengthwise between rows of vines in vineyards, seldom in extensive fields. It grows only in dry, stony ground.

When planted, the plants need no further care, and are left undisturbed for two to three years. Then the gathering of the rhizomes commences, and their cutting, cleaning, and preparation for the market requires patient and tiresome labor. Generally, the root is harvested in the third year, but when prices are high and profitable, it is frequently already cut in the second year of the growth of the plant. But when this is not the case, it is preferable to cut the root in the third year, because it is then larger, fuller, and of finer appearance than the meager biennial root. On the other hand, 100 kilos of green biennial roots yield about 40 kilos of dry root, while the three years' old root furnishes but 30 to 35 per cent. of dry root. The age of the root may readily be recognized by the two or three fold joints. Half of the last joint remains on the living plant, as this is replanted after the roots have been cut off. The replanting is done at once or within fourteen days in new ground. The old ground is left for recovery for at least one year, but may meanwhile be used for raising cereals. The freshly cut roots are first placed in water in order to facilitate peeling, and then exposed to the sun for drying. This is generally accomplished within fourteen days.

Orris roots from Morocco and East India have lately been brought into the market in considerable quantities, but they are utterly unfit for distillation and perfumery. Their miserable appearance bears evidence of the fact that no care is taken in the proper culture and preparation of the root.—Schimmel's Report; The Pharmaceutical Era.



ARUNDINARIA NITIDA, TOGETHER WITH DETAILS OF EDGE AND BACK OF LEAF, ENLARGED TEN-FOLD, AND A FULL-SIZED LEAF AND SHOOT.

BAMBOOS.

AT the meeting of the Royal Horticultural Society on July 26 last, two fine representative collections of bamboos were shown by A. B. Freeman-Mitford, Esq., of Batsford Park, Moreton-in-the-Marsh. We now afford our readers illustrations of a specimen of Arundinaria nitida, A. The plant measures seven feet in height and ten feet in diameter. We append the following descriptive notes kindly furnished by Mr. Freeman-Mitford:

Arundinaria nitida (Mitford), a beautiful and graceful Arundinaria from northern Ssu Chuen. The slender purple stems grow to a height of upward of ten feet, so far as the plant has hitherto been proved. They, as a rule, do not branch until the second year, when there are but few leaves; but in the third year they are literally borne down to the ground by the weight of most

brilliant foliage; and these three stages in the life of the stems give the plant a most graceful and attractive effect.—The Gardeners' Chronicle.

"THE NEO-OCCULTISM."*

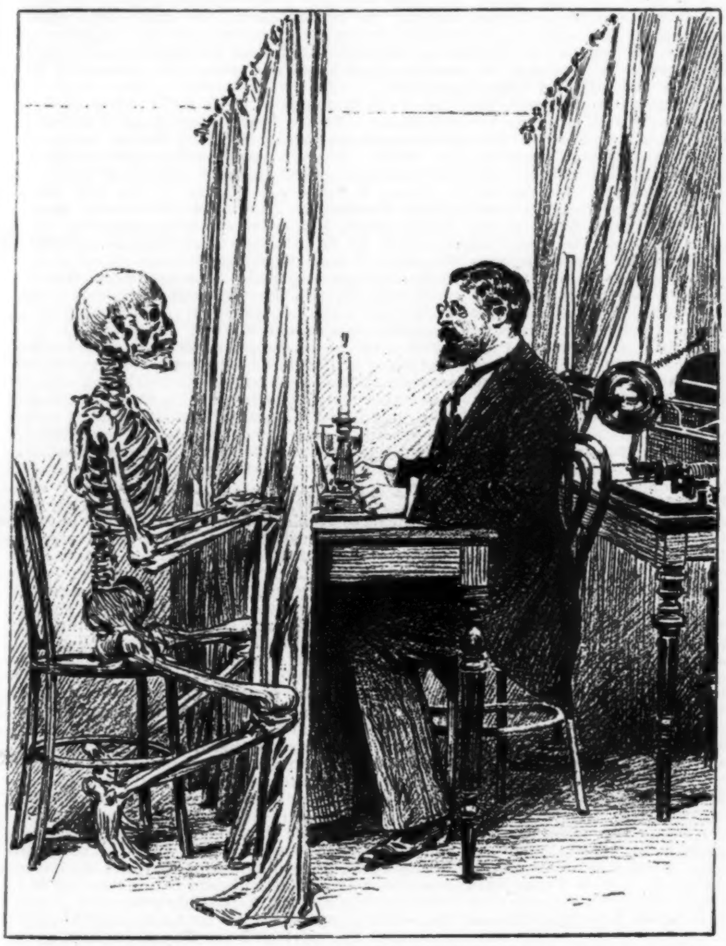
THE X rays, after becoming the indispensable coadjutors of surgeons, and even of physicians, are now competing with the most noted mediums in the domain of the marvelous.

M. Radiguet, the well known manufacturer of physical apparatus, has been devoting himself for a long time to experiments with the Roentgen rays in the laboratory, which is encumbered with electric lamps, lamp globes, and glass apparatus of all kinds. One day he perceived that these glass objects, under the action of the X rays, shone in the darkness. Here again was an amusing and perhaps a useful experiment due to accident. Useful, because the radiographs obtained up to the present, by means of artificial screens, have been really good only when the sensitive bodies have been in small crystals. In a pulverulent state they are nearly insensible to the X rays, and it is almost impossible to obtain the grain of the screen upon the photographic plate. It is easy, on the contrary, to work the glass in such a way as to prevent any irregularity in the radiograph. Such experiments will certainly be made ere long, but, for the present, it is the fantastic side of the discovery that we shall present to our readers.

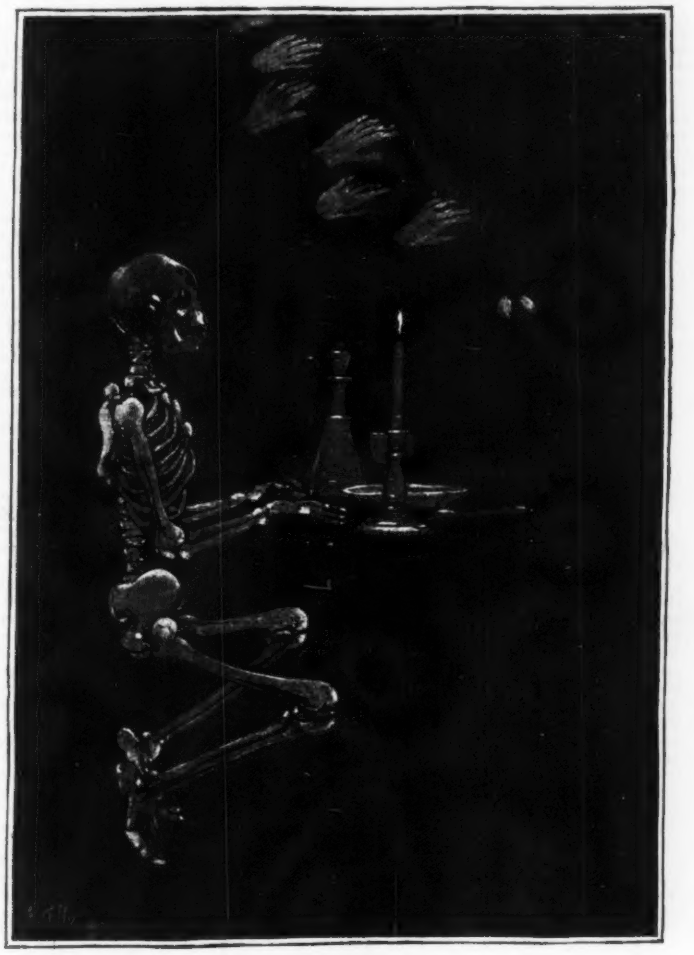
Porcelain, enamels, and diamonds, and also objects covered with platinocyanides (used by Roentgen) and with calcium tungstate, zinc sulphate, etc., have, like glass, the property of becoming luminous in darkness under the action of the X rays. We have, therefore, only the trouble of selection in order to get up a "spirit séance" with every certainty of success, while genuine spiritual séances fail in most cases, as well known, because the spirits are in an ill mood and disposed to be coy.

The following will prove a scene sufficiently weird to put the most intrepid worldlings in a flurry if some one of our friends takes it into his head to give them the mysterious spectacle thereof before they have read an exposure of the trick.

The first figure that we present herewith exhibits a Ruhmkorff coil, which is placed here to show the operation in its entirety. But, as the first effect of its vibrations would be to attract the attention, and, consequently, the suspicions of the spectators, whom it is a question of transporting into the domain of the marvelous, this apparatus is relegated to some distant room. The current that produces the X rays is led into the Crookes tube by wires. This apparatus, more over, which is not very bulky, may be placed behind a door or be concealed under black cloth. The objects designed to become luminous are placed as near to the tube as possible. In the experiment under consideration a diner (who is doubtless near-sighted, since he wears eyeglasses) is about to do justice to his breakfast. Armed with a knife and fork, he attacks his beefsteak; but he is assuredly a greater eater than drinker, since he contents himself with water, while his light consists of a single candle.



ARRANGEMENT FOR A STRIKING EXPERIMENT WITH THE X RAYS.



THE APPARITION.

A black curtain on the other side of the table conceals from the spectators a skeleton covered with zinc sulphide.

Let us now put out the light and set the Ruhmkorff coil in action. What a surprise ! A plate, a glass, a water bottle, and a candle shine in space with the light of glow-worms.

A sinister guest in the form of a skeleton sits opposite the place occupied by the near-sighted gentleman, who has disappeared, and whose eyeglasses alone have held their own before this ghastly apparition. Finally, to complete the illusion, hands are seen moving over the heads of the spectators, and those multiply, and then disappear, only to appear anew.

It must be remarked that, in order to render the experiment more conclusive, it is allowable for the most incredulous members of the party to tie the gentleman tightly to his chair, and, if they desire, to hold his hands and feet during the entire time of the experiment. It is scarcely necessary to explain how the latter is performed. The X rays pass through the black cloth on the door that conceals the Crookes tube and also through the body of the gentleman, and render luminous the glass objects covered with zinc sulphide. As for the mysterious hands, those are simply gloves covered with the same substance and fixed to the extremity of long sticks that are moved in all directions by confederates.

Such scenes may naturally be varied to infinity; and the spirit of invention is so fertile, there is no doubt that before long ladies will be giving a place in the programme of their soirées to this up-to-date spiritualism.

* Copyrighted translation from L'Illustration by Munn & Company, 1897.—From Magic: Stage Illusions and Scientific Diversions, including Trick Photography.

THE DANGERS OF ACETYLENE.*

By M. AD. BOUVIER.

PURE acetylene has no monopoly of power of causing accidents; but the accidents due to it have been frequent and serious enough to demand attentive consideration.

The lighting power is about fifteen times that of coal gas, the heating power more than twice. Every burner has a best pressure, generally from 1·2 inch to 1·6 inch water. A new Bray 0000 burner, using 0·95 cubic foot per hour, gives 43½ candles with a pressure of 1·28 inch; but the burner is hopelessly blocked in twenty hours (Weber). Billwiller's burners (two converging jets at right angles to one another dragging air with them) work for months on end, giving 26 candles for 0·77 cubic foot per hour. The temperature of combustion should be very high, 2,500° C.; but it is lower (900° C.) than that of the Welsbach mantle (1,400° C.) The flame of acetylene is a succession of minute explosions analogous to a discharge of rockets. At the German mint an acetylene Bunsen flame rapidly got up temperatures above 1,500° C., and melted in thirty minutes a quantity of nickel which had previously taken eighty-five minutes. The flame is bright and very actinic (photographic), the spectrum is very like that of sunlight, and colors are distinguishable in the light.

Acetylene and air are explosive within a very wide range of proportions, from 5 to 62 per cent. (Le Chatelier), 3 to 72, or even 80 (Bunte), instead of 8 to 30, as in the case of coal gas. The fiercest explosion takes place with 1 acetylene to 9 air. Pure acetylene at the atmospheric pressure decomposes at 750° C.; a mixture of at least 35 per cent. of air with acetylene decomposes at 480° C. (Le Chatelier). At a works in Veszprem, Hungary, the yield at which is 5,250 cubic feet per hour, the temperature is kept below 30° C., so as to keep down impurities. The phosphureted hydrogen goes up to 0·95 per cent., and the arseniureted hydrogen up to 1·71 per cent. The light is 8·77 candles for 0·3 to 0·325 cubic foot per hour; and it has been noted there that acetylene dried over carbide very rapidly dries up the joints of the pipes, so that these become leaky.

Compression of acetylene increases the rapidity of propagation of combustion and lowers the kindling temperature. At 2 atmospheres it is explosive, even in a tube 160 inches long and 0·8 inch in diameter (Berthelot). Gerde's experiments in acetylene at 6 atmospheres show how heat applied to a pipe causes an explosion of the gas holder 60 inches away, the pipe being 0·2 inch in diameter. At 0° C. and 26 atmospheres pressure, 855 liters of gas become 2·2 liters of liquid, of specific gravity 0·45 (water being 1). The liquid is extremely expansible, so that we should never fill a cylinder with liquid acetylene to more than three-tenths its capacity. Acetylene is readily frozen to snow. At 15° C. the pressure exerted by liquid acetylene is 38 atmospheres; at 38° C. it is 68 atmospheres; but beyond this temperature (36·9° according to Ansdell and Gerde) it is not possible for the acetylene to remain liquid; and there is no recipient strong enough to stand the pressure induced by its reassuming the gaseous condition, for the gas produced would be at a pressure above 6,000 atmospheres, and the too venturesome experimenter would run a risk of forgetting what the observed pressure was. The pressure becomes so high because of the heat liberated on the break up of the endothermic compound.

One cubic foot of liquefied acetylene represents 360 cubic feet of acetylene gas; 1 cubic foot of carbide represents 660 cubic feet of gas; the respective weights are 28⅛ and 137½ pounds per cubic foot. But the question seems to be settled so far as regards liquefied acetylene, which is now prohibited by law in most countries of Europe. Acetylene dissolved in acetone under pressure is also complicated; and recourse must be had to the carbide itself for the lighting of vehicles, etc., so that we have to consider the best means of overcoming the difficulties incident to producing the acetylene as it is required.

M. Bouvier went on to give a long list of accidents due to acetylene during 1896 and 1897. These were twenty-nine in number, resulting in nineteen deaths; but his list was not exhaustive. The dangers incident to producing acetylene as it is required seem to be the following:

1. Local heating of carbide to a red heat, when not completely covered by water, in a vessel from which the gas is not allowed freely to escape; the compressed gas is highly explosive under such conditions.
2. Irregular rushes of gas when the lime falls off the carbide (bicycle lamp explosion at Lyons).
3. The easy kindling of the gas, by a soldering iron or a cigarette, 480° C.
4. The extreme rapidity of propagation of flame in an explosive mixture of air and acetylene, especially under pressure.
5. The wider limits of explosibility.
6. The slow diffusion between escaped acetylene and

* Paper read before the Société Technique du Gaz, 1898. Abstract.

the surrounding air, the two gases having very nearly the same specific gravity—acetylene 0·91 and air 1·00.

7. The rapid permeability of rubber by acetylene.

8. The shattering character of the explosion of mixtures of air and acetylene.

9. The circumstance that compressed acetylene of which a certain quantity near the mouthpiece has become mixed with air will go off as a whole if that small quantity of the mixture be fired, for the irritation is enough to cause decomposition and evolution of heat, which travels through the whole bulk.

10. The spreading backward of an explosion in the same way where local heating is induced by allowing the gas to rush at too high a pressure through too small an aperture.

11. The accidental impurities of acetylene, siliciureted and phosphureted hydrogen and ammonia.

The risks, then, are undeniable. Can they be avoided? There are only two methods of using acetylene other than pure acetylene. These are dissolved acetylene and diluted acetylene. As to the former, acetone dissolves, practically, 200 times its volume at 12 atmospheres pressure; about one-third the gas that may be obtained from an equal bulk of carbide. But it seems that the running back of a flame might do terrible havoc, for the acetylene going off will get up a high pressure, and at 20 atmospheres the acetone would go off, too. In any case, 12 atmospheres pressure means a heavy recipient. As to dilution, acetylene has been diluted with air, even by lecturers on the subject, in the United States. Then came nitrogen, but of this nothing much seems to have come. Then came carbonic acid, which is a promising idea (Kruger, Charlottenburg, 1895; Goodwin, Dublin). The Paris municipal laboratory experiments settled it that 10 or even 20 per cent. of carbonic acid affects the lighting value of acetylene by less than 10 per cent. of its amount. It seems as if the carbonic acid played the same part as the thoria in a mantle does in relation to the ceria, according to Dr. Bunte's explanation. Carbonic acid greatly reduces the risk of explosion, but it does not seem to be known what its effect is as regards the deposition of carbon in the burners. It enables acetylene to be used in motors, by diminishing the violence of the explosion. One inventor worked up dry carbide, a dry bicarbonate, and a dry acid, so that the product, which he called "acetyline," might give off a mixture of acetylene and carbonic acid; but nothing seems to be heard of this now.

M. Bouvier went on to discuss the use of acetylene mixed with coal gas and with oil gas, giving data with which for the most part our readers are no doubt already familiar. The conclusions to which he comes are that acetylene with oil gas is practical; acetylene with carbonic acid is probably so; acetylene alone is risky; and portable acetylene lamps may actually be considered to be dangerous.

[Continued from Supplement, No. 1188, page 19049.]

INAUGURAL ADDRESS BY SIR WILLIAM CROOKES, F.R.S., V.P.C.S., PRESIDENT OF THE BRITISH ASSOCIATION.

Cheap production of wheat depends on a variety of causes, varying greatly in different countries. Taking the cost of producing a given quantity of wheat in the United Kingdom at 100s., the cost for the same amount in the United States is 67s., in India 66s., and in Russia 54s. We require cheap labor, fertile soil, easy transportation to market, low taxation and rent, and no export or import duties. Labor will rise in price, and fertility diminish as the requisite manurial constituents in the virgin soil become exhausted. Facility of transportation to market will be aided by railways, but these are slow and costly to construct, and it will not pay to carry wheat by rail beyond a certain distance. These considerations show that the price of wheat tends to increase. On the other hand, the artificial impediments of taxation and customs duties tend to diminish as demand increases and prices rise.

I have said that starvation may be averted through the laboratory. Before we are in the grip of actual dearth the chemist will step in and postpone the day of famine to so distant a period that we, and our sons and grandsons, may legitimately live without undue solicitude for the future.

It is now recognized that all crops require what is called a "dominant" manure. Some need nitrogen, some potash, others phosphates. Wheat pre-eminently demands nitrogen, fixed in the form of ammonia or nitric acid. All other necessary constituents exist in the soil; but nitrogen is mainly of atmospheric origin, and is rendered "fixed" by a slow and precarious process which requires a combination of rare meteorological and geographical conditions to enable it to advance at a sufficiently rapid rate to become of commercial importance.

There are several sources of available nitrogen. The distillation of coal in the process of gas making yields a certain amount of its nitrogen in the form of ammonia; and this product, as sulphate of ammonia, is a substance of considerable commercial value to gas companies. But the quantity produced is comparatively small; all Europe does not yield more than 400,000 annual tons, and, in view of the unlimited nitrogen required to substantially increase the world's wheat crop, this slight amount of coal ammonia is not of much significance. For a long time guano has been one of the most important sources of nitrogenous manures, but guano deposits are so near exhaustion that they may be dismissed from consideration.

Much has been said of late years, and many hopes raised by the discovery of Hellriegel and Wilfarth, that leguminous plants bear on their roots nodosities abounding in bacteria endowed with the property of fixing atmospheric nitrogen; and it is proposed that the necessary amount of nitrogen demanded by grain crops should be supplied to the soil by cropping it with clover and plowing in the plant when its nitrogen assimilation is complete. But it is questionable whether such a mode of procedure will lead to the lucrative stimulation of crops. It must be admitted that practice has long been ahead of science, and for ages farmers have valued and cultivated leguminous crops. The four-course rotation is turnips, barley, clover, wheat—a sequence popular more than two thousand years ago. On the Continent, in certain localities, there has been some extension of microbe cultivation; at home we have not reached even the experimental stage. Our present knowledge leads to the conclusion that the much more frequent growth of clover on the same land, even with successful microbe-seeding and proper mineral supplies, would be attended with uncertainty and difficulties. The land soon becomes what is called "clover sick" and turns barren.

There is still another and invaluable source of fixed nitrogen. I mean the treasure locked up in the sewage and drainage of our towns. Individually the amount so lost is trifling, but multiply the loss by the number of inhabitants, and we have the startling fact that, in the United Kingdom, we are content to hurry down our drains and water-courses, into the sea, fixed nitrogen to the value of no less than £16,000,000 per annum. This unspeakable waste continues, and no effective and universal method is yet contrived of converting sewage into corn. Of this barbaric waste of manurial constituents Liebig, nearly half a century ago, wrote in these prophetic words: "Nothing will more certainly consummate the ruin of England than a scarcity of fertilizers—it means a scarcity of food. It is impossible that such a sinful violation of the divine laws of nature should forever remain unpunished; and the time will probably come for England, sooner than for any other country, when with all her wealth in gold, iron, and coal, she will be unable to buy one-thousandth part of the food which she has, during hundreds of years, thrown recklessly away."

The more widely this wasteful system is extended, recklessly returning to the sea what we have taken from the land, the more surely and quickly will the finite stocks of nitrogen locked up in the soils of the world become exhausted. Let us remember that the plant creates nothing; there is nothing in bread which is not absorbed from the soil, and unless the abstracted nitrogen is returned to the soil, its fertility must ultimately be exhausted. When we apply to the land nitrate of soda, sulphate of ammonia, or guano we are drawing on the earth's capital, and our drafts will not perpetually be honored. Already we see that a virgin soil cropped for several years loses its productive powers, and without artificial aid becomes infertile. Thus the strain to meet demands is increasingly great. Witness the yield of forty bushels of wheat per acre under favorable conditions, dwindling through exhaustion of soil to less than seven bushels of poor grain, and the urgency of husbanding the limited store of fixed nitrogen becomes apparent. The store of nitrogen in the atmosphere is practically unlimited, but it is fixed and rendered assimilable by plants only by cosmic processes of extreme slowness. The nitrogen which with a light heart we liberate in a battleship broadside has taken millions of minute organisms patiently working for centuries to win from the atmosphere.

The only available compound containing sufficient fixed nitrogen to be used on a world-wide scale as a nitrogenous manure is nitrate of soda, or Chile saltpeter. This substance occurs native over a narrow band of the plain of Tamarugal, in the northern provinces of Chile between the Andes and the coast hills. In this rainless district for countless ages the continuous fixation of atmospheric nitrogen by the soil, its conversion into nitrate by the slow transformation of billions of nitrifying organisms, its combination with soda, and the crystallization of the nitrate have been steadily proceeding, until the nitrate fields of Chile have become of vast commercial importance, and promise to be of inestimably greater value in the future. The growing exports of nitrate from Chile at present amount to about 1,200,000 tons.

The present acreage devoted to the world's growth of wheat is about 163,000,000 acres. At the average of 12·7 bushels per acre, this gives 2,070,000,000 bushels. But thirty years hence the demand will be 3,260,000,000 bushels, and there will be difficulty in finding the necessary acreage on which to grow the additional amount required. By increasing the present yield per acre from 12·7 to 20 bushels we should with our present acreage secure a crop of the requisite amount. Now from 12·7 to 20 bushels per acre is a moderate increase of productiveness, and there is no doubt that a dressing with nitrate of soda will give this increase and more.

The action of nitrate of soda in improving the yield of wheat has been studied practically by Sir John Lawes and Sir Henry Gilbert on their experimental field at Rothamsted. This field was sown with wheat for thirteen consecutive years without manure, and yielded an average of 11·9 bushels to the acre. For the next thirteen years it was sown with wheat, and dressed with 5 cwt. of nitrate of soda per acre, other mineral constituents also being present. The average yield for these years was 36·4 bushels per acre—an increase of 24·5 bushels. In other words, 22·86 pounds of nitrate of soda produce an increase of one bushel of wheat.

At this rate, to increase the world's crop of wheat by 7·3 bushels, about 1½ cwt. of nitrate of soda must annually be applied to each acre. The amount required to raise the world's crop on 163,000,000 acres from the present supply of 2,070,000,000 bushels to the required 3,260,000,000 bushels will be 12,000,000 tons distributed in varying amounts over the wheat growing countries of the world. The countries which produce more than the average of 12·7 bushels will require less, and those below the average will require more; but, broadly speaking, about 12,000,000 tons annually of nitrate of soda will be required, in addition to the 1,250,000 tons already absorbed by the world.

It is difficult to get trustworthy estimates of the amount of nitrate surviving in the niter beds. Common rumor declares the supply to be inexhaustible, but cautious local authorities state that at the present rate of export, of over 1,000,000 tons per annum, the raw material "caliche," containing from 25 to 50 per cent. nitrate, will be exhausted in from twenty to thirty years.

Dr. Newton, who has spent years on the nitrate fields, tells me there is a lower class material, containing a small proportion of nitrate, which cannot at present be used, but which may ultimately be manufactured at a profit. Apart from a few of the more scientific manufacturers, no one is sanguine enough to think this debatable material will ever be worth working. If we assume a liberal estimate for nitrate obtained from the lower grade deposit, and say that it will equal in quantity that from the richer quality, the supply may last, possibly, fifty years, at the rate of 1,000,000 tons a year; but at the rate required to augment the world's supply of wheat to the point demanded thirty years hence, it will not last more than four years.

I have passed in review all the wheat growing countries of the world, with the exception of those whose united supplies are so small as to make little appreciable difference to the argument. The situation may be summed up briefly thus: The world's demand for wheat—the leading bread stuff—increases in a crescendo ratio year by year. Gradually all the wheat bearing land on the globe is appropriated to wheat growing, until we are within measurable distance of using the last available acre. We must then rely on nitrogenous manures to increase the fertility of the land under wheat, so as to raise the yield from the world's low average—12·7 bushels per acre—to a higher average. To do this efficiently and feed the bread eaters for a few years will exhaust all the available store of nitrate of soda. For years past we have been spending fixed nitrogen at a culpably extravagant rate, heedless of the fact that it is fixed with extreme slowness and difficulty, while its liberation in the free state takes place always with rapidity and sometimes with explosive violence.

Some years ago Mr. Stanley Jevons uttered a note of warning as to the near exhaustion of our British coalfields. But the exhaustion of the world's stock of fixed nitrogen is a matter of far greater importance. It means not only a catastrophe little short of starvation for the wheat eaters, but indirectly, scarcity for those who exist on inferior grains, together with a lower standard of living for meat eaters, scarcity of mutton and beef, and even the extinction of gunpowder.

There is a gleam of light amid this darkness of despondency. In its free state nitrogen is one of the most abundant and pervading bodies on the face of the earth. Every square yard of the earth's surface has nitrogen gas pressing down on it to the extent of about 7 tons—but this is in the free state, and wheat demands it fixed. To convey this idea in an object lesson, I may tell you that, previous to its destruction by fire, Colston Hall, measuring 146 feet by 80 feet by 70 feet, contained 27 tons weight of nitrogen in its atmosphere; it also contained one-third of a ton of argon. In the free gaseous state this nitrogen is worthless; combined in the form of nitrate of soda it would be worth about £2,000.

For years past attempts have been made to effect the fixation of atmospheric nitrogen, and some of the processes have met with sufficient partial success to warrant experimentalists in pushing their trials still further; but I think I am right in saying that no process has yet been brought to the notice of scientific or commercial men which can be considered successful either as regards cost or yield of product. It is possible, by several methods, to fix a certain amount of atmospheric nitrogen; but to the best of my knowledge no process has hitherto converted more than a small amount, and this at a cost largely in excess of the present market value of fixed nitrogen.

The fixation of atmospheric nitrogen therefore is one of the great discoveries awaiting the ingenuity of chemists. It is certainly deeply important in its practical bearings on the future welfare and happiness of the civilized races of mankind. This unfulfilled problem, which so far has eluded the strenuous attempts of those who have tried to wrest the secret from nature, differs materially from other chemical discoveries which are in the air, so to speak, but are not yet matured. The fixation of nitrogen is vital to the progress of civilized humanity. Other discoveries minister to our increased intellectual comfort, luxury, or convenience; they serve to make life easier, to hasten the acquisition of wealth, or to save time, health, or worry. The fixation of nitrogen is a question of the not far distant future. Unless we can class it among certainties to come, the great Caucasian race will cease to be foremost in the world, and will be squeezed out of existence by races to whom wheaten bread is not the staff of life.

Let me see if it is not possible even now to solve the momentous problem. As far back as 1892 I exhibited, at one of the soirées of the Royal Society, an experiment on "The Flame of Burning Nitrogen." I showed that nitrogen is a combustible gas, and the reason why, when once ignited, the flame does not spread through the atmosphere and deluge the world in a sea of nitric acid is that its igniting point is higher than the temperature of its flame—not, therefore, hot enough to set fire to the adjacent mixture. But by passing a strong induction current between terminals the air takes fire and continues to burn with a powerful flame, producing nitrous and nitric acids. This inconsiderable experiment may not unlikely lead to the development of a mighty industry destined to solve the great food problem. With the object of burning out nitrogen from air so as to leave argon behind, Lord Rayleigh fitted up apparatus for performing the operation on a larger scale, and succeeded in effecting the union of 29·4 grammes of mixed nitrogen and oxygen at an expenditure of one horse power. Following these figures, it would require one Board of Trade unit to form 74 grammes of nitrate of soda, and therefore 14,000 units to form one ton. To generate electricity in the ordinary way with steam engines and dynamos, it is now possible with a steady load night and day, and engines working at maximum efficiency, to produce current at a cost of one-third of a penny per Board of Trade unit. At this rate one ton of nitrate of soda would cost £26. But electricity from coal and steam engines is too costly for large industrial purposes; at Niagara, where water power is used, electricity can be sold at a profit for one-seventeenth of a penny per Board of Trade unit. At this rate nitrate of soda would cost not more than £5 per ton. But the limit of cost is not yet reached, and it must be remembered that the initial data are derived from small scale experiments, in which the object was not economy, but rather to demonstrate the practicability of the combustion method, and to utilize it for isolating argon. Even now electric nitrate at £5 a ton compares favorably with Chile nitrate at £7 10s. a ton; and all experience shows that when the road has been pointed out by a small laboratory experiment, the industrial operations that may follow

are always conducted at a cost considerably lower than could be anticipated from the laboratory figures.

Before we decide that electric nitrate is a commercial possibility, a final question must be mooted. We are dealing with wholesale figures, and must take care that we are not simply shifting difficulties a little further back without really diminishing them. We start with a shortage of wheat, and the natural remedy is to put more land under cultivation. As the land cannot be stretched, and there is so much of it and no more, the object is to render the available area more productive by a dressing with nitrate of soda. But nitrate of soda is limited in quantity, and will soon be exhausted. Human ingenuity can contend even with these apparently hopeless difficulties. Nitrate can be produced artificially by the combustion of the atmosphere.

Here we come to finality in one direction: our stores are inexhaustible. But how about electricity? Can we generate enough energy to produce 12,000,000 tons of nitrate of soda annually? A preliminary calculation shows that there need be no fear on that score. Niagara alone is capable of supplying the required electric energy without much lessening its mighty flow.

The future can take care of itself. The artificial production of nitrate is clearly within view, and by its aid the land devoted to wheat can be brought up to the thirty bushels per acre standard. In days to come, when the demand may again overtake supply, we may safely leave our successors to grapple with the stupendous food problem.

And, in the next generation, instead of trusting mainly to food stuffs which flourish in temperate climates, we probably shall trust more and more to the exuberant food stuffs of the tropics, where, instead of one yearly sober harvest, jeopardized by any shrinkage of the scanty days of summer weather, or of the few steady inches of rainfall, nature annually supplies heat and water enough to ripen two or three successive crops of food stuffs in extraordinary abundance. To mention one plant alone, Humboldt—from what precise statistics I know not—computed that, acre for acre, the food productiveness of the banana is 133 times that of wheat; the unripe banana, before its starch is converted into sugar, is said to make excellent bread.

Considerations like these must in the end determine the range and avenues of commerce, perhaps the fate of continents. We must develop and guide Nature's latent energies, we must utilize her inmost workshops, we must call into commercial existence Central Africa and Brazil to redress the balance of Odessa and Chicago.

Having kept you for the last half hour rigorously chained to earth, disclosing dreary possibilities, it will be a relief to soar to the heights of pure science and to discuss a point or two touching its latest achievements and aspirations. The low temperature researches which bring such renown to Prof. Dewar and to his laboratory in the Royal Institution have been crowned during the present year by the conquest of one of Nature's most defiant strongholds. On May 10 last Prof. Dewar wrote to me these simple but victorious words: "This evening I have succeeded in liquefying both hydrogen and helium. The second stage of low temperature work has begun." Static hydrogen boils at a temperature of 238° C. at ordinary pressure, and at 250° C. in a vacuum, thus enabling us to get within 23° C. of absolute zero. The density of liquid hydrogen is only one-fourteenth that of water, yet in spite of such a low density it collects well, drops easily, and has a well defined meniscus. With proper isolation it will be as easy to manipulate liquid hydrogen as liquid air.

The investigation of the properties of bodies brought near the absolute zero of temperature is certain to give results of extraordinary importance. Already platinum resistance thermometers are becoming useless, as the temperature of boiling hydrogen is but a few degrees from the point where the resistance of platinum would be practically nothing, or the conductivity infinite.

Several years ago I pondered on the constitution of matter in what I ventured to call the fourth state. I endeavored to probe the tormenting mystery of the atom. What is the atom? Is a single atom in space solid, liquid, or gaseous? Each of these states involves ideas which can only pertain to vast collections of atoms. Whether, like Newton, we try to visualize an atom as a hard, spherical body, or, with Boscovitch and Faraday, to regard it as a center of force, or accept the vortex atom theory of Lord Kelvin, an isolated atom is an unknown entity difficult to conceive. The properties of matter—solid, liquid, gaseous—are due to molecules in a state of motion. Therefore, matter as we know it involves essentially a mode of motion; and the atom itself—intangible, invisible, and inconceivable—is its material basis, and may, indeed, be styled the only true matter. The space involved in the motions of atoms has no more pretension to be called matter than the sphere of influence of a body of riflemen—the sphere filled with flying leaden missiles—has to be called lead. Since what we call matter essentially involves a mode of motion, and since at the temperature of absolute zero all atomic motions would stop, it follows that matter as we know it would at that paralyzing temperature probably entirely change its properties. Although a discussion of the ultimate absolute properties of matter is purely speculative, it can hardly be barren, considering that in our laboratories we are now within moderate distance of the absolute zero of temperature.

I have dwelt on the value and importance of nitrogen, but I must not omit to bring to your notice those little known and curiously related elements which during the past twelve months have been discovered and partly described by Prof. Ramsay and Dr. Travers. For many years my own work has been among what I may call the waste heaps of the mineral elements. Prof. Ramsay is dealing with vagrant atoms of an astral nature. During the course of the present year he has announced the existence of no fewer than three new gases — krypton, neon, and metargon. Whether these gases, chiefly known by their spectra, are true unalterable elements or whether they are compounded of other known or unknown bodies, has yet to be proved. Fellow workers freely pay tribute to the painstaking zeal with which Prof. Ramsay has conducted a difficult research, and to the philosophic subtlety brought to bear on his investigations. But, like most discoverers, he has not escaped the flail of severe criticism.

There is still another claimant for celestial honors. Prof. Nasini tells us he has discovered, in some volcanic gases at Pozzuoli, that hypothetical element coronium, supposed to cause the bright line 5316·9 in the spectrum of the sun's corona. Analogy points to its being lighter and more diffusible than hydrogen, and a study of its properties cannot fail to yield striking results. Still awaiting discovery by the fortunate spectroscopist are the unknown celestial elements aurorium, with a characteristic line at 5570·7, and nebulum, having two bright lines at 5007·05 and 4959·02.

The fundamental discovery by Hertz, of the electromagnetic waves predicted more than thirty years ago by Clerk Maxwell, seems likely to develop in the direction of a practical application which excites keen interest—I mean the application to electric signaling across moderate distances without connecting wires. The feasibility of this method of signaling has been demonstrated by several experimenters at more than one meeting of the British Association, though most elaborately and with many optical refinements by Oliver Lodge at the Oxford meeting in 1894. But not until Signor Marconi induced the British post office and foreign governments to try large-scale experiments did wireless signaling become generally and popularly known or practically developed as a special kind of telegraphy. Its feasibility depends on the discovery of a singularly sensitive detector for Hertz waves—a detector whose sensitiveness in some cases seems almost to compare with that of the eye itself. The fact noticed by Oliver Lodge in 1889 that an infinitesimal metallic gap subjected to an electric jerk became conducting, so as to complete an electric circuit, was rediscovered soon afterward in a more tangible and definite form, and applied to the detection of Hertz waves by M. E. Branly. Oliver Lodge then continued the work, and produced the vacuum filing-tube coherers with automatic tapper-back, which are of acknowledged practical service. It is this varying continuity of contact under the influence of extremely feeble electric stimulus alternating with mechanical tremor which, in combination with the mode of producing the waves revealed by Hertz, constitutes the essential and fundamental feature of "wireless telegraphy." There is a curious and widely spread misapprehension about coherers to the effect that to make a coherer work the wave must fall upon it. Oliver Lodge has disproved this fallacy. Let the wave fall on a suitable receiver, such as a metallic wire, or, better still, on an arrangement of metal wings resembling a Hertz sender, and the waves set up oscillating currents which may be led by wires (inclosed in metal pipes) to the coherer. The coherer acts apparently by a species of end-impact of the oscillatory current, and does not need to be attacked in the flank by the waves themselves. This interesting method of signaling—already developing in Marconi's hands into a successful practical system which inevitably will be largely used in lighthouse and marine work—presents more analogy to optical signals by flashlight than to what is usually understood as electric telegraphy; notwithstanding the fact that an ordinary Morse instrument at one end responds to the movements of a key at the other, or, as arranged by Alexander Muirhead, a siphon recorder responds to an automatic transmitter at about the rate of slow cable telegraphy. But, although no apparent optical apparatus is employed, it remains true that the impulse travels from sender to receiver by essentially the same process as that which enables a flash of magnesium powder to excite a distant eye.

The phenomenon discovered by Zeeman that a source of radiation is affected by a strong magnetic field in such a way that light of one refrangibility becomes divided usually into three components, two of which are displaced by diffraction analysis on either side of the mean position, and are oppositely polarized to the third or residual constituent, has been examined by many observers in all countries. The phenomenon has been subjected to photography with conspicuously successful results by Prof. T. Preston, in Dublin, and by Prof. Michelson and Dr. Ames and others in America.

It appears that the different lines in the spectrum are differently affected, some of them being tripled with different grades of relative intensity, some doubled, some quadrupled, some sextupled, and some left unchanged. Even the two components of the D lines are not similarly influenced. Moreover, whereas the polarization is usually such as to indicate that motions of a negative ion or electron constitute the source of light, a few lines are stated by the observers at Baltimore, who used what they call the "small" grating of five inches width ruled with 65,000 lines, to be polarized in the reverse way.

(To be continued.)

MUSICAL SUSCEPTIBILITY OF ANIMALS.

By Nicolas Pike.

In the study of animals, particularly those of the higher order, I have come to the conclusion that their minds do not differ very materially from those of man, and that they possess the same affections, virtues, moral sense, and capacity for education, and are liable to the same kind of mental disorders. There are many scientists that advance the theory that the various species of animals have different languages, just as the language of man is divided by social and natural lines. There are many people, however, who will not admit the fact that animals are intelligent, such as the elephant, horse, mule, dog, cat, and pig, that often exhibit degrees of intellection which is impossible to distinguish from reason. I am of the opinion that all animals are susceptible to the sounds of music. I have come to this conclusion after a careful study of over half a century. I shall speak only of those animals that have come under my personal observation. I know of no animal that exhibits such a marked trait, in common with a similar one in human kind, as the elephant. It is one of the most intelligent animals on the earth. They like harmonious sounds, and easily learn to mark time and to move in steps to the sound of music. The sweet tones of the harp and organ please them very much. They will move their ears and sway their bodies from right to left as long as the music continues. I once visited a gentleman in the East Indies who had a number of elephants on his plantation. One afternoon, while seated on the veranda of his house, in conversation with one of his daughters, I noticed the animals hastening toward the residence. A young lady was playing the organ in the parlor. When they had approached as near to the dwelling as they could, they commenced to raise their trunks over their backs, flap their ears, and evinced great pleasure in listening to the melodious sounds. I was informed that, whenever the organ was played, it was the usual custom for the animals to make their appearance, as they were exceedingly fond of music. I was once traveling over the mountains of Portugal mounted on a mule's back, which had a string of musical bells around his neck. In passing a narrow defile these bells got loose, rolled down a ravine, and were lost. The mule would not move on. The muleteer could not replace the bells, as the members of our party had gone far ahead. He resorted to playing on the guitar and singing. This had the effect of moving the animal, but when this ceased he would stop, but on resuming the music, would prick his ears and move on. Thus it will be seen that the animal has an appreciation for musical sounds. I have known the deer to come out of the dense forests and stand in open, unsheltered places, in order to listen to the shrill notes of the cornet. With head erect, they would stand and listen as long as the instrument was played. Cows are very partial to music. I have seen them gather around a group of persons singing in chorus, elevating their heads, and moving their bodies from right to the left, seemingly keeping time to the music. This was to my mind a sure indication of their appreciation of the harmonious sounds they were listening to.

The power of singing has more than once been the means of rescuing people from certain death through threatening stampede of wild cattle on the prairies of America. Sheep are very fond of the shepherd pipes and flute, and often gather around the shepherd while he is playing. This fact is corroborated by the pastoral poetry of almost every age. The dog and cat, for example, can discriminate between different tones in the human voice, and even between different notes in music. A dog was noticed invariably to howl at the note D, whether played or sung; and Gautier writes of a cat that had a similar dislike to the note G, and always tried to silence the note or the person producing the sound. Were we desired to propose a creature to be an emblem of incorruptible fidelity, unwavering friendship, forbearing and enduring affection, combined with all that renders gratitude commendable, and honesty of high value, we know not one more to be distinguished than the dog. We had one of the Dachshund breed, presented to us by a friend. He was such an ugly-looking creature that we named him "Quilp," after one of Dickens' characters. This dog was one of the most intelligent animals of the kind I ever met with. I could teach him almost anything but to speak. Oftentimes he would come to the parlor door when he heard the music from the piano; he would run to the corner of the room and seize two little American flags mounted on sticks, and bring them in his mouth and lay them at my feet before me. Raising himself on his hind feet, I would place the flags one under each fore paw, and he would waltz around the room, keeping time to the music. This animal was exceedingly fond of the piano. A short time ago I was passing a month in a small house on Grape Island, near Ipswich, Mass., for the purpose of hunting and fishing. While there, I was invited to join a picnic party of ladies and gentlemen, which was to take place on the bluff at the entrance of the bay. A yacht was to convey us to the place. We had four amateur musicians in the party who discoursed sweet music, as we sailed along with a light wind. In a few minutes after the music commenced, a seal appeared on the surface of the water, a short distance from the stern of the boat, following us, seemingly delighted with the music. The pretty creature appeared almost human. Swaying his body on this side and then on that, he appeared (as the ladies declared) as if he wanted to come on board. He followed us till we reached the shore, when he disappeared. On our return in the afternoon he appeared again, and remained with us so long as the music continued. On the following evening, just before dark, the musicians played on a little jetty which extended on the bay, and, strange to say, a pair of seals made their appearance, probably a male and female, and remained as a very appreciative audience as long as the music lasted.

The seals all have a musical taste. I could speak of other cases which have come under my observation. Some years ago I wished to ascertain what effect music would have upon bees. Oftentimes I seated myself near the apiary, and played my flageolet. Near by was a large field of clover, and on one occasion I noticed a pair of ground hogs (woodchucks) sitting upon their haunches looking directly toward me. At first I paid little attention to them, but as they repeated their visits day after day, when I played, I felt sure they were there to listen to the music. One day I took a cornet with me and played it, but they did not appear. On the following day the flageolet was used again, and they came very near to me, and remained in an erect position till I finished playing, when they disappeared. It was evident that the soft and melodious notes of the flageolet pleased them. Mice are fond of music! I have known a number of instances of their being perfectly charmed with it. A young lady friend made what is termed in New England the Æolian harp, which she fixed in her bed-room window. This harp, so called, is nothing more than sewing silk placed tightly between the sashes of the window. The wind drawing through and over the strings makes a very pretty, soft, musical sound. One day, as she sat reading in her room, near the window, she observed a mouse moving in front of her. Presently another made its appearance, till she had an audience of six mice, all intent on the musical sounds. Not being afraid of mice, she arose from her seat and carefully stopped the music without frightening them. They remained silent for a few moments and then ran away. After a few minutes the music was resumed, they all appeared again, and came still nearer her person, making a faint squealing noise. For days the coming of the mice was a regular thing. They became exceedingly tame, and the young lady protected and made pets of them. She many times invited her lady friends to visit her in order to witness the singular spec-

tacle of the mice gamboling around her, chirping like little birds. Naturalists believe that most animals are sagacious in proportion as they cultivate society. Latude, during his thirty years' confinement in the Bastile, made companions of the rats and mice, and whiled away his tedious hours in teaching those that visited his cell. He improvised a small musical instrument. The first notes from it startled the rats, and, one by one, they came around him as if charmed by the simple notes. Finally he taught them many little performances to the magic spell of music.

We were once invited to witness the performance of a large albino rat, the pet of a young lady who was curious to have me see the animal, and satisfy myself that it was really fond of music. It was very tame and was given its liberty in the house. It would sit up on its hind feet, and send forth three musical sounds, which were in unison with those of the piano which the young lady was playing. At the same time he made a movement, first with his right paw and then with his left, rising and falling, keeping perfect time with the music. It was a wonderful performance and pleased me exceedingly.

In some parts of India, where snakes abound, the inhabitants frequently employ a professional snake charmer to rid the district of them. It is really marvelous how he does this. While in India, I saw them at work a number of times. The charmer enters the bush with his associates and they at once commence to play on their tom-toms (small drums) and clarinets. They walk slowly through the jungle, playing weird tunes in the minor key. Snakes of every description soon make their appearance, following the musicians, who walk slowly backward, keeping up their weird tunes. At this stage the tom-toms are beaten lightly, and sometimes omitted. Snakes by the hundred are seen crawling and wriggling all around, coming from all parts of the jungle. It was a sight to behold! Not one moment did the musicians cease their music. If they had, the charm would be lost or broken. The serpents were entranced with the music, and seemed to lose all consciousness of their surroundings. They were led into an inclosure by the charmer and destroyed, not one snake being left in the neighborhood. The love of music led them to their destruction!

The singing of birds implies a certain appreciation of melody. They listen with attention and imitate the strains which take their fancy. Birds have undoubtedly very keen sense of hearing. Thrushes may often be seen intently listening for worms under ground.

A gentleman living in Brooklyn who was a great admirer of birds had a large upper room in his house converted into an aviary. Small trees and pots of shrubs were placed in this room. The floor was sanded, and made as comfortable as possible for bird life. Sparrows, thrushes, catbirds, robins, and other birds were placed in pairs in this room and they soon became a happy family. Some of the birds mated. One year after the aviary had been established I visited it, and the music from their tiny little throats was delightful to my ear. A music box was brought into the room and placed upon the floor, and set a-going. The birds stopped chirping. The catbird was the first to alight near the music box, the robin and woodthrush next, till nearly all the birds were near the box, intently listening to the music. When this ceased the birds all returned to the trees. The music was again resumed in one hour, with the same result, all gathering around the box listening attentively to every note. This exhibition was given to satisfy me that birds were great lovers of soft, sweet, and melodious sounds of music. A young lady had a pet pigeon which was exceedingly tame. When she commenced to play her piano in the morning, the little pet bird would come to her parlor window and tap with its bill on the window panes, to come in; and when admitted would walk up to the piano, and lie at the player's feet, and all during the music express his admiration in a gentle cooing. This little creature is a great pet, but will leave any one to listen to music.

The house sparrow has been known to imitate the canary when confined together. The mocking bird and the mocking wren will imitate any bird in the forest. I have taught the parrot and the miner bird to talk and sing. While at my shooting box at Grape Island, Mass., fishing and shooting, my little house was directly on the salt meadow. There was a large, beautiful, yellow and black spider, Epeira riparia, which interested me very much. I collected a large number of specimens and gave them their liberty on the veranda of my little house, so that I could study their habits during my leisure hours. They immediately commenced to spin all over the place. It was a sight to behold. One morning I was playing my guitar and singing, when, to my astonishment, the spiders began letting themselves down by a single thread in front of me. Many of them began to ascend and descend, seemingly pleased with the sweet notes of my instrument. As long as I played they continued these movements, which were discontinued when I ceased singing and playing. This continued every day during my stay there. From experiments which I have made since, I am certain that all spiders appreciate and love sweet, harmonious sounds. Music is the power that attracts many animals. They seem to lose all consciousness of their surroundings, and some of them will follow at will when under its influence, particularly the snake. My observations go to establish this fact. I could enumerate many more animals which have come under my observation that are fond of music, but space in this article will not admit it.

The River Pollution Commissioners' standards of permissible composition of sewage effluents are: Organic carbon, 2·0; organic nitrogen, 0·3; albuminoid ammonia, nil; absorbed oxygen, nil; in parts per 100,000. The commissioners also require that a certain degree of alkalinity or acidity is not to be exceeded three parts per 100,000 of dry mineral matter, nor one part of dry organic matter. That there shall be no visible color in a stratum 1 in. deep when viewed in a white dish, nor any metal except calcium, magnesium, potassium, or sodium present to a greater extent than two parts per 100,000; while a limit is also set to free chlorine, arsenic, and sulphur as sulphureted hydrogen or free sulphuric acid. The Thames Conservancy in the upper reaches of the river recognize as a "good effluent" any effluent which gives less than 0·2 part per million of albuminoid ammonia.

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PUBLISHED WEEKLY.

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